COMPRESSED AIR

AND EVERYTHING PNEUMATIC

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THE MELTING AND BURNING OF IRON IN COMPRESSED AIR

There are current in the technical press of the day accounts of many entirely unrelated developements in the line indicated by the above title. That iron will burn fiercely in oxygen was frequently shown in laboratory and lecture room experiments two or three generations ago. The burning of a watch spring in a jar of oxygen is in all the old school books of physics or natural philosophy. The commercial production of oxygen in unlimited quantities and at low prices is leading now to its extensive and growing employment in our most important industries.

BURNING OUT BLAST FURNACE TAP HOLES.

Robert Grimshaw in the *Engineering and Mining Journal* describes the process invented by Dr. Menne, of Krenztal in Westpalia, of clearing the tap holes of blast furnaces, using compressed oxygen as the agent with the aid also of hydrogen as a starter. "The hydrogen is first turned on when the gas is ignited, the oxygen control valve is opened, the pressure being well throttled down until the iron is white hot. Then the pressure of the oxygen is raised until the cast iron commences to burn, which is indicated by strong sparking. The oxygen pressure is again raised, this time to about 450 lb. per sq. in., and the hydrogen is shut off. From this point on, the fuel is iron, instead of hydrogen, and consequently there is a greater development of heat.

Hydrogen and oxygen alone would not melt through the solidified mass, because the great volume of gases necessary would cause excessive loss of heat by radiation and conduction. One kilogram of hydrogen develops in combustion with oxygen about 13,057 calories, while the same weight of iron develops only 748. But a given weight of hydrogen takes up 87,234 times more room than the same weight of iron. Thus one volume of iron, burned in oxygen, develops $87{,}234 \times 748 \div 13{,}057 = 5{,}012$ times as much heat as the same volume of hydrogen under the same conditions.

"In burning the iron the heat developed is concentrated in a small space; and this accounts for the enormous temperature and the rapid action of the combustion on the frozen tap hole. The stream of gas not only melts the iron, but also blows it away from the hole. A slag hole or a tuyere opening an inch or so in diameter may be freed from solid iron without injuring the walls, which are cooled by the action of the stream of gas under the high pressure employed. When hydrogen is not available, generator gas or ordinary illuminating gas may be used to start the operation."

COMPRESSED AIR FOR WELDING.

In the Bessemer process compressed air alone is blown up through a mass of molten iron, raising its temperature with great rapidity, burning out first all the carbon and then, if the operation is continued, the iron also, affording throughout one of the most brilliant pyrotechnic displays ever produced. While this process has been widely and constantly employed for forty or fifty years, most suggestive as it has been of other possibilities, it seems to be only lately coming to be realized that a jet of compressed air with sufficient pressure to give it the required velocity can alone supply sufficient oxygen to cause red hot iron to burn. There are indications, however, that the air jet will soon be in familiar and frequent use in every blacksmith shop, or, what is now nearly the same thing, in every blacksmith shop in which a supply of compressed air is maintained.

W. C. Whelan, Foreman Blacksmith, Kansas City, writes as follows:

"I took a piece of two-inch round iron,

brought the end to a low welding heat, and by turning on about eighteen-pounds pressure, burned off three inches of the iron. I then brought two pieces of two-inch round iron to a very low welding heat (a heat which could not be welded successfully in the ordinary way), and by applying the air made a successful butt weld, which we bent back and forth over the anvil without a fracture developing. After testing in other ways, I am convinced that all small hammers, forging machines, flue-welding machines, and also all heavy fires, where V-welds are made in frames, or, in fact, any fire where a clean, safe weld is required, should be equipped with air, either by a small, round nozzle, or a flat nozzle if the work done is on a wide piece. I believe that in welding frames on engine or anvil this process will hold the heat until the work is completed, and all dirt and foreign substances are eliminated."

Mr. Geo. A. Hortline, Blacksmith Foreman at the Collinwood shops of the L. S. & M. S. Ry., writes as follows to the *Railway Journal:*

One of the small kinks in the Collinwood shops that has helped us in successful welding in the forging machine, is a compressed air jet used for bringing two pieces of iron to a point of fusion immediately before the stroke of the forging machine.

While some blacksmiths may be familiar with this method, we find it is new with many others. A very interesting experiment to demonstrate the possibilities with this method is to heat a bar of one inch or one and one-fourth inch iron on the end for five or six inches, then blow a stream of air against the end of the bar parallel with its length; a beautiful display of fireworks will be the result, the temperature of the bar will be raised to a point of fusion and the bar will melt away as in the foundry cupola.

We have been quite successful in making large crank pin nuts with the aid of this method. A piece of bar iron 2 x ⅞ in. is rounded up under the hammer, each end of the bar being sheared to an angle of 45 degrees so as to form a lap. These pieces of iron are heated in an oil furnace, placed between the dies of the forging machine, a jet of air is blown against the two ends, which cleans out all dirt and scale and raises the temperature of the metal to a welding heat, one stroke of the machine insuring a perfect weld with clean metal.

The same method is used in welding the cross bar on our clinker hooks for locomotive service. The end of the long rod and a short bar are both heated to a welding heat in our oil furnace; the long rod is butted against the short piece and placed between the dies, where it comes in contact with the jet of compressed air, which blows out all scale and dirt, bringing the two pieces to a perfect welding heat and one stroke of the machine completes the weld and upsets the metal so as to strengthen the hook at the point of intersection.

In reparing and welding broken spokes or rims in steel driving wheels we think the compressed air jet is indispensable. Some of the wheels are very difficult to handle owing to the counterbalance, and it is very difficult to get a wheel from the fire to the anvil without losing the heat. By using the compressed air jet it is possible to revive the heat and the parts to be welded will retain a welding heat after the operation is complete. In welding spokes in steel wheels we use the "V" weld. The heat is taken on a side fire and just before the piece is welded into the spoke the compressed air jet is brought in contact with the hot metal, keeping the temperature of the metal up to a welding heat until the operation is completed. Care must be taken, however, in applying this compressed air jet, as it would be possible to burn a spoke in two if held at one point too long.

TESTING STEEL BY ITS SPARKS.

Another phase of the combustion of iron in air is presented in an interesting article which recently appeared in the *American Machinist,* in which the writer suggested the sparking of steel when ground on an emery wheel or when filings are thrown into a flame as a means of determinining the character of the steel. "In the former case," the writer says, "there must be enough strength to resist wear or cutting in order to heat the detached particles, and this heat must be intense enough to cause oxidation, while in the latter case, the metal must be subject to combustion at the temperature of the flame, without volatilization, before any amount of light is produced. Now the action of grinding or of a candle flame cannot produce heat enough to volatilize iron or steel, but the heat imparted is ample to cause chemical combination between the oxygen of the air

and the iron, which in the process of combustion causes heat of sufficient intensity to ignite the carbon contained in the iron and especially steel.

"This fact is beautifully demonstrated by the iron torch, shown in Fig. 1. By heating a bar

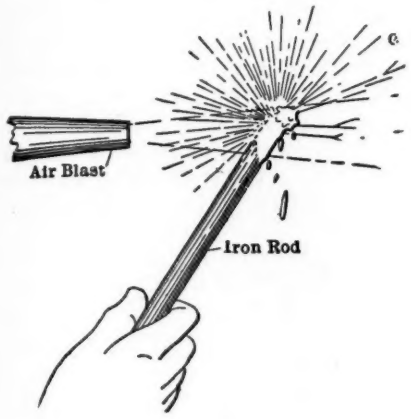


FIG. 1.—BURNING IRON IN THE AIR BLAST.

of iron to a welding heat and then holding it in a stronge air blast, it will at once begin to boil and sizzle, emitting a dazzling bluish-white light. This may be maintained for hours without any source of heat, except that caused by the combustion of the iron. Beginning with let us say slag iron, which is almost free from carbon, the spark test will usually give straight lines, which become broader and more luminous some distance (not over a few inches) from their source, and then disappear as they started (see 1 of Fig. 2). This peculiarity is probably due to the action of the oxygen on the heated particles requiring some time to act. This effect is at its maximum when spark streak appears broadest and whitest, and would continue so, but for the reason that the fuel supply is soon exhausted.

"By adding a very small percentage of carbon to iron the effect is at once noticeable by a division or forking of the luminous streaks, as in 2 of Fig. 2. This is owing to the presence of the carbon, which is only acted on by the maximum heat of the iron spark, and which then burns explosively, causing a break in the original heavy line. By adding more and more carbon to the steel, the iron lines become less and less conspicuous, and the star-like explosions not only become extremely profuse, but their rays often divide again and subdivide, causing a beautiful display of curves and figures, as in 3. In this instance it should be stated that the iron and carbon have been so united that they are most easily attacked by the oxygen, and hence the great danger of burning tool steel in the process of forging. This readiness to burn may be considerably reduced by the addition of a more refractive metal as tungsten or molybdenum. The former alloy shows not only anti-rusting qualities but also can endure incandescent heat without scaling or burning. The temper is thus not drawn so easily and hence the name, high-speed steel.

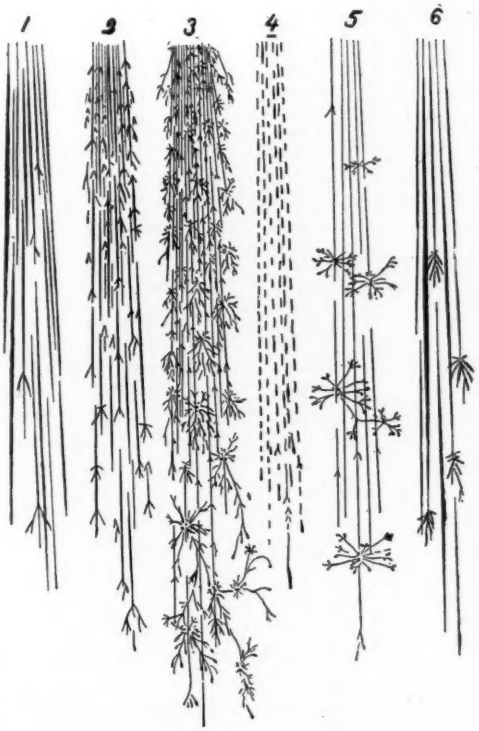


FIG. 2.—TESTING BY THE SPARKS.

"In the spark test these peculiarities are shown as indicated by 4 and 6, in which the sparks appear not only simple, but also very dull red. This, however, is easily understood by referring to the foregoing paragraphs where it is shown that the luminosity of iron or steel

sparks depends for the most part on the combustion of the iron and carbon. Perhaps one of the most remarkable sparks which enter into this groop is characteristic of manganese, and widely differs from the familiar carbon stars and rays. Once these divirsified signs have been carefully studied, the trained eye will detect the slightest trace of manganese in even what is otherwise pure carbon steel. Its spark is shown in 5. The lateral darts always radiate from an unbroken line and at right angles thereto. The color is dull red and each dart is subdivided into a number of white hot globules.

"Some steelmakers in testing their products use the method of spark analysis in addition to others, and they agree that it is very reliable. There are also many mechanics who by experience have learned thus to distinguish tool steel from iron or machinery steel, and who are never caught making reamers and cutters of machinery steel or bolts and screws of tool steel.

"Perhaps the most misleading spark to be found is the one of gray or cast iron, which being very seldom of a standard purity will often show scarcely any luminous sparks at all. Sometimes it is rich in manganese, and the familiar bright manganese darts are given off at varying distances from the source of heat. Cast iron usually consists of iron with a very high percentage of carbon. Graphite in iron is that form of carbon which is not chemically united, and, therefore, it follows that since it exists in a free state, it must be present in all stages of combination. Thus cast iron will yield sparks ranging from iron to tool steel. In addition to the diversified sparks shown in the diagram there is also much significance in the distance at which they appear from the source of heat, as in grinding, which is the most accurate test."

DIFFERENT EXPERIENCES OF DIVERS AND CAISSON WORKERS

In the British Societies and in the technical press discussion continues as to the effect of compressed air upon the workers in it, the most noticeable feature being the differences in the experiences of submarine divers and the workers in caissons. Staff-Surgeon Oswald Reeves, R. N., Secretary to the Admirality Committee on Deep Diving, has prepared a memorandum on Caisson Disease which has been summarized by the *Engineer,* whose work we still further condense, more or less.

As a diver descends in the water, air is pumped to him and the pressure equals or only slightly exceeds that of the water at the head of the exhaust valve of the helmet. The caisson worker is seldom subjected to a greater pressure than 40 lbs., while a diver at 35 fathoms is exposed to a pressure of 93.6 lbs.

When a gas is in contact with a liquid on which it has no chemical action it is absorbed by the liquid in amounts which are proportional to the pressure under which the gas is at the time, and in the case of a mixture of gases each gas is absorbed as if it alone were present. In the lungs the air is practically in contact with the blood and each of the gases in the atmospheric mixture; oxygen, nitrogen and carbon dioxide, is absorbed in its due proportion. The oxygen is used up by the tissues, and the $C O^2$ is kept at a fixed percentage, no matter what amount is present in the air breathed. Nitrogen is absorbed unaltered and in an amount directly proportioned to the pressure.

So long as the diver remains under pressure there is no manifestation of the pressure of the absorbed gas, but as soon as the pressure is released as the diver ascends the gas should begin to bubble off. Fortunately, the blood is a sticky albuminous fluid in which bubbles do not form easily, and is capable of being supersaturated with nitrogen to twice its normal amount without the formation of bubbles. Fat can take up six times the amount of nitrogen that the blood can absorb. The comparative freedom of the diver from attacks of "the bends" is probably because his blood never becomes saturated as he is exposed to pressure for shorter periods than the caisson worker. The severity of the symptons in caisson disease bears a distinct ratio to the time of onset after the return of the diver to the surface; the quicker the onset the more severe the symptons, and *vice versa.*

A man who carries about with him a huge reservoir for nitrogen, as is provided by the abdominal fat, must, other things being equal, be more liable to the formation of bubbles than the thin, spare man. In fatal cases after sudden decompression bubbles have been

found in the abdominal fat when there were none in the other tissues.

In cases collected the percentage ratio of illness to age was as follows:

Age.	Per cent of Illness.
15-20	....
20-25	10.3
25-30	14.3
30-35	20.9
35-40	22.9
40-45	26.3
45-50	66.0

The following indicates the influence of bodily habit on health:

	Spare.	Medium.	Heavy.
Men generally well.	25	14	3
Men taken sick....	26	22	36
Men paralyzed	2	3	8
Men died	..	..	3

Safety in decompression may be secured by two methods. 1. Limiting the time of exposure; 2, bringing the diver up slowly. In caisson work it has been found that by limiting the time of exposure to the compressed air cases of paralysis have been practically eliminated.

Various rates of decompression have been suggested, usually from twelve minutes to twenty minutes per atmosphere. The blood as it leaves the left side of the heart is always saturated with air to the existing pressure, and, in the same way will be desaturated to the same pressure. The blood leaves the arteries in less than half a minute, and in this time bubbles scarcely seem to form, so that there will be little risk of their actual formation in the arterial blood unless the ebulition is practically instantaneous. With very rapid decompression, however, small bubbles which have passed through the capillaries of the lungs may easily increase in size in the arteries.

This, however, is not the whole of the problem. All the blood passes through the lungs once a minute, and as it is at once desaturated to the existing pressure danger would cease one minute after sudden decompression, but, unfortunately, the saturation of the tissues must be considered.

Cases of accident are almost non-existent when the air pressure is less than 20 lbs., gage, and this immunity would seem to be due to the fact that bubbles will not readily form as long as the relative diminution of pressure is kept at a rate of 1 to 2.

In coming up from 33 feet to the surface, or from 99 to 33 feet, 165 to 66 feet, or 231 to 99 feet there should be no formation of bubbles, and, generally decompression can be safely proceeded with if the difference between the relative pressures of the air and nitrogen dissolved in the blood and tissues is not more than in the proportion of about 2 to 1.

This assumption is of great practical importance, as desaturation will naturally go on faster the greater the relative difference we can establish without undue risk. In gradual and equal decompression the absolute difference between the air pressure and the nitrogen pressure in the tissues necessarily goes on increasing, and is greatest at the end of the process. It is the *relative* and not the absolute difference in the nitrogen pressure that matters, so that the unsuitability of uniform decompression is evident.

The great advantage of the "stage" method has been proved by experiment. It was found that the time required to desaturate a diver who was completely saturated with nitrogen at 41 lbs., 95 feet, was at least 90 minutes. In 30 fathoms, 80 lbs., 3¼ hours would be required. Such a length of time is impossible for the diver, so it was found necessary to limit the extent of saturation, and tables have been prepared giving a scale of times that divers may be allowed to stay in deep water.

Bubbles once formed in any tissue of the body are liable to increase in size as long as the pressure of nitrogen in that tissue is greater than that of the air, and symptons may therefore go on increasing in intensity for two or three hours after decompression.

Researches of several investigators in this line, often carried out with much personal risk, have revolutionized the practice of compressed air working. It is now possible to carry out operations under air pressures and at depths formerly out of the question, provided due precautions and suitable methods of working are adopted. Lieut. Damont, the recently appointed inspector of diving in Great Britain, has descended to a depth of 210 feet witohut detriment to health, this being the record for diving work.

A BIG MEXICAN DRAINAGE TUNNEL

A tunnel of length and magnitude comparable with those of the Alps was begun some fifteen years ago near Pachuca, Mexico, for the drainage of the mines of Atotonilco el Chico and those adjoining. The work has progressed slowly, but there is prospect that now it will be pushed so rapidly that it will be finished in four years.

The tunnel is about 650 feet lower than the lowest mine in the vicinity. The total length of the tunnel will be over 6 miles, of which up to this time only about one mile has been driven at a cost of $142,000. A new water power plant is being installed near the tunnel, and electric air drills will be employed, when it is expected that progress will be made at the rate of 50 or 60 feet per week.

This tunnel commences at an altitude of 6,500 feet, and about a mile and a half to the north of Atotonilco el Chico, right at the junction of the rivers Milagro and Puente. The actual direction of the tunnel is 20 degs. 40 min. S. E. in order to pass near the California shaft which will be used for ventilation. Its direction then changes so that it will pass a little to the east of San Pedro shaft, then toward San Rafael and other mines north of Pachuca. The section of the tunnel is nearly 12 feet vertical and horizontal. To give the water an easy flow, and also that the cars may run by their own gravity the incline is 5-1000.

Although the tunnel is ostensibly a charitable enterprise, its earnings when completed being intended to be used for the erection and maintenance of a home for invalids and orphans in Pachuca, important practical results are expected from it, among which are the following: The possibility of making, at a depth never before reached by more than 300 meters, a very economical exploitation of all of the mineral veins of El Chico located in the mines of that company and that of Arevalo. This exploration could be made by means of a cut commenced from the Nepton, as the tunnel is named, and continued horizontally east and west inside of the respective claims without expense of constructing buildings, and with great economy in the way of management, drainage and extraction of ore.

The shaft of the California once crossed, the Nepton will change its course slightly to the west in order to connect with some of the cuts to the north of Pachuca. This long course will also make it possible to determine the structure and formation of the mountains that separate the mineral regions now known as Pachuca and Atotonilco el Chico, it being supposed that silver veins exist there.

Arriving, at two-thirds of its length, under the small surface of the Sabanilla the tunnel will cross the base of the boulders of crests of las Ventanas at a depth of 900 meters (the greatest) which should produce an increase in the temperature.

When the tunnel is in communication with the mines in the vicinity of Pachuca it will give them permanent and secure drainage and a cheaper extraction, making the same one-eighth of what it is at present. With these facilities it is expected that many new mines will be opened which will augment the riches of the republic.

The veins near Pachuca being reached it will be easy to follow any of them toward Real del Mone, and either in or out of a vein to Santa Gertrudis. The road being finished to San Juan and equipped with its indispensable railroad it would serve for traffic and could be used from Amajac towards the districts of Atotonilco, Metztitlan, Zacualtipan, etc., saving time, trouble and expense and avoiding the fatigue and time consumed by way of Britos or Casas Quemadas.

THE COST OF LAYING 6 AND 8-INCH WROUGHT-IRON SCREW-JOINT PIPE FOR AIR

By E. E. Harper.*

During the summer of 1907 the writer had occasion to lay about 7,000 ft. of 8-in. and 4,000 ft. of 6-in. well casing, to be used as an air line for compressed air at 80 to 90 lbs. pressure. Very careful attention was given to the cost of this work. In view of the scarcity of similar cost data, if any be available, I submit my itemized figures to the profession through your columns.

The work was all performed by common labor, none of the men being experienced in pipe-laying. The accompanying tables give the cost per 100 ft. of laying the 6-in. and 8-in. casing. The illustrations show the de-

*Of Ward & Harper, Civil and Mining Engineers, Sturgis, Ky.

COST OF LAYING 6 AND 8-IN. (OUTSIDE DIAMETER) WROUGHT-IRON AIR-SUPPLY PIPE FOR THE FEDERAL LEAD CO., FLAT RIVER, MO.

6-IN., FROM NO. 9 SHAFT TO NO. 10 SHAFT.

Item.	Cost per 100 ft.	Remarks.
1 Size and kind	....	6-in. O.D. lap-welded casing. Weight, 15 lbs. per ft. Av. length of joints, 20.1 ft. Laid with sleeve couplings, 11½ threads per in. Flange union every 150 ft. U-bends for expansion every 500 ft.
2 Length	....	4118 ft.
3 Surveying and superintendence	$0.70	
4 Cost of laying	3.137	Actual cost of connecting pipe. Cost per joint, 62.5c.
5 Av. ft. laid per day	....	*588.2 = 29.3 joints.
6 Crew and wages	....	Av. Crew, 4.85 men at 20c.; 1 foreman at 30c.; 1 waterboy at 10c. See premium schedule.
7 Clearing right-of-way	0.327	Small brush, etc. Cut line 10 ft. wide.
8 Hauling and distr.	1.578	Av. haul, 3,000 ft. bad roads, steep and rough. Includes loading pipe on cars and unloading and hauling and distr. Teams and drivers $3 per day. Incl. 7 U-bends.
9 Blocking to grade	0.116	Includes temporary blocking and bending pipe in 5 places by building fires on same.
10 Cost of bents	0.45	Carpenter work only. About 20 bents. Av. 3 ft. height. 4 × 6-in. stuff.
11 Anchors for U-bends	2.29	8 piers, ¾ cu. yd. each, $12 each, incl. bolts and clamps. (Est. cost.)
12 Painting	0.90	Paint, $1 per gal. Labor, 20c. per hr. Pipe cleaned with wire brushes. Given 1 coat mineral paint. (Est. cost.)
13 Tools	0.10	Shopwork, depreciation.
14 Testing	0.30	(Est. cost.)
15 Total cost of laying	9.898	
16 Cost of pipe	....	
17 Weather, etc.	....	Weather fair except 1 day. Men worked in rain 4 hrs. and laid 22 joints. Men walked 2½ to 3 miles to and from work. Time, Aug. 15 to 24, '07.

*Best day's work, 1065 ft. or 53 joints by 6 men, incl. foreman, or 177.5 ft. each, actual time 9 hrs. (See 17); 2d best day's work 883 ft. or 44 joints by 6 men, incl. foreman, or 147.1 ft. each, actual time 9 hrs. (See 17); poorest day's work 120 ft. or 6 joints by 6 men, incl. foreman, or 20 ft. each, actual time 9½ hrs. (See 17). No excuse except poor judgment and bad management of foreman.

8-IN., FROM NO. 3 MILL TO NO. 9 SHAFT.

Item.	Cost per 100 ft.	Remarks.
1 Size & kind of pipe	....	8-in. O. D. Lap-welded casing. Weight, 20 lbs. per ft. Av. length of joints, 19.15 ft. Laid with sleeve couplings, 11½ threads per in. Flange union every 150 ft. U-bends for expansion every 600 ft.
2 Length of line	....	7,101 ft.
3 Surveying and superintendence	$1.00	
4 Cost of laying	3.58	Actual cost of connecting pipe. Cost per joint, 69.3c.
5 Av. ft. laid per day	....	*503.6 per day of 10 hrs. = 26.3 joints.
6 Crew and wages	....	Av. crew, 5.92 men at 20c. per hr.; 1 foreman at 30c.; 1 waterboy at 10c. per hr. See premium schedule.
7 Clearing right of way	0.187	Small brush, etc. Cut line 10 ft. wide.
8 Hauling and distr. pipe	1.0321	Incl. 12 U-bends, which cost $1 each to haul. Team and drivers at 30c. per hr.; laborers, at 20c.; foreman at 30c. per hr.
9 Blocking to grade	1.11	Temporary Supports. Bents put in afterward.
10 Cost of bents	1.0687	Carpenter work only. Abt. 80 bents of 4 × 6-in. stuff from 1 to 16 ft. high; av. 6 ft. high; spaced 30 ft. apart.
11 Anchors for U-bends	2.535	12 piers at 1 cu. yd. each, $15 each, incl. bolts and clamps.
12 Painting	1.20	Paint, $1 per gal. Labor, 20c. per hr. Pipe cleaned with wire brushes. Given 1 coat mineral paint.
13 Tools	0.1022	Shop work, depreciation, etc.
14 Testing	0.388	Includes laying & connecting 200 ft. of 4-in. pipe to pump line. Tested to 110 lbs. hydraulic pressure. Leaks developed at two tees in line, and these were repaired. Line tested again and found O. K.
15 Total cost of laying	12.203	Not including cost of pipe.
16 Cost of pipe	76.40	F.O.B. McKeesport, Pa., 76c.; frt. McKeesport to Flat River, 40c.
17 Weather, etc.	....	July 2, '07, to Aug. 5, '07, weather hot and sultry most of time. Thermometer from 85° to 100° in shade; ave., 90°.

*Best day's work, 613 ft. or 32 joints by 6 men, incl. foreman, or 102 ft. each; 2d best day's work, 675 ft. or 35 joints by 7 men, incl. foreman, or 96.4 ft. each; poorest day's work, 380 ft. or 20 joints by 7 men, incl. foreman, or 54 each.

vices used to facilitiate the work. The greatest cause of delays in laying screwed pipe is the difficulty in getting each successive length of pipe into line and keeping it there until the first threads take hold and the pipe begins to screw together. To overcome this difficulty a cradle for supporting the pipe at the joint, a jack for adjusting and supporting the outer end of the pipe and a straight-edge for lining the pipe were de-

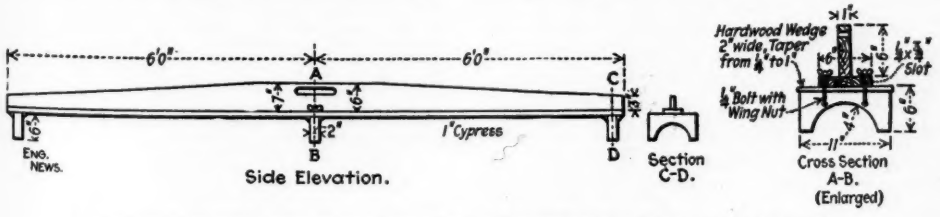


FIG 1.—STRAIGHT-EDGE USED IN CONNECTING SBREW-JOINT WROUGHT-IRON PIPE. (Adjusted as tested on a straight length of pipe.)

vised. The cradle holds the threaded end of the pipe in position to enter the sleeve coupling on the last joint laid; the jack allows both vertical and horizontal adjustment of the joint of pipe; and the straight-edge shows when the pipe is in line ready to screw together. The cradle was simply a wood block,

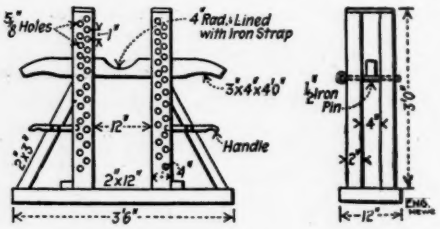


FIG. 2—JACK AND CRADLE.

8 x 8 ins. x 24 ins. in length, with a groove having a 4-in. radius cut in its top. The jack is shown by Fig. 2, and the straight-edge by Fig. 1. The movable block on the straight-edge (Fig. 1) is necessary because it is almost impossible to make a 12-ft. straight-edge that will remain true for more than a day.

***PREMIUM SCHEDULE FOR LAYING 8-IN. PIPE.**

After working four days the following schedule was adopted and the men were paid according to the number of joints laid per day. No deduction was made for U-bends or fittings.

A U-bend counted as 1 joint.

For every man added to the crew, add 3 joints.

For every man less than the crew, deduct 3 joints.

In counting joints, any odd joints carried forward and counted next day. Thus, 28 joints gives 11 hrs. time with 2 joints to credit of crew for next day's work.

Schedule for 5 men, 1 foreman, 1 waterboy.

22 joints (or less)	10 hrs. time for crew
26 joints	11 hrs. time for crew
29 joints	12 hrs. time for crew
32 joints	13 hrs. time for crew
35 joints	14 hrs. time for crew
38 joints	15 hrs. time for crew
41 joints	16 hrs. time for crew
44 joints	17 hrs. time for crew
47 joints	18 hrs. time for crew
50 joints	19 hrs. time for crew
53 joints	20 hrs. time for crew

***Same schedule used in laying 6-in. pipe, except that size of crew was reduced by one man.**

These devices saved fully 50 per cent. over the crude and unsatisfactory method of using blocks to hold the pipe in line. There was no straining and lifting to hold the pipe in place, and as the pipes were started together straight there were no stripped threads and bad joints, and the pipe made up so easily that one man with a pair of 3-ft. tongs often screwed an 8-in. pipe half way up; it was then completed by four men using two pairs of tongs with 8-ft. handles.

The threads, both male and female, were cleaned with wire brushes. Dixon's pipe joint compound was used on all screwed joints. Ring gaskets of 1-16-in. rainbow packing were used on flange joints (see table), the gasket being pasted to one flange with coal-tar roofing paint, which held it in position while the joint was being made.

The premium schedule (see foot note to table) allowing overtime if more than a certain amount of pipe was laid per day, proved quite satisfactory and kept the men hustling. —*Engineering News.*

DRYING AIR FOR BLAST FURNACES

British patent No. 25112 of 1906 describes an interesting method of drying the air used in blast furnaces. A salt is used which takes up water of crystallization without deliquescing and which subsequently gives up its water at a comparatively low temperature. The sulphates of zinc, copper or magnesium are the most suitable. In preparing the drying apparatus, porous material, such as common brick, is immersed in saturated solutions of the sulphate and so impregnated with the hydrated salt. The bricks are then built up into the drying chamber, and subjected to heating by means of hot air or some inert gas. The water of crystalization is thus driven off and the bricks are then ready for dealing with the blast as it comes from the blowing engine. In practice, the drying chambers will be arranged in pairs so that one is drying the blast while the other is having its water of crystallization removed by the hot air, and the pair of chambers will be fitted with suitable reversing valves.

PNEUMATIC HAMMER POWER TESTS

The Engineer, London, did an excellent and eminently practical thing in arranging for a test of pneumatic hammers in regular blacksmith work for the purpose of determining the power consumed in operating them. The tests were made at the works of Messrs. B. and S. Massey, Openshaw, England. There were three hammers with falling weights of 1, 3 and 7 hundred weights respectively.

Fig. 1 shows the largest hammer from which the common type may be understood. It will

be seen that they were not steam hammers of the regular type with compressed air substituted for steam as the actuating fluid, but were actuated by alternate pulsations of air from the inclined air cylinder at the side, the piston of this cylinder being driven from a horizontal crank-shaft belted to a line-shaft overhead. Only the actual air pressure required is produced; the air works with full advantage of its expansion, it being in fact merely a spring between the pulsator piston and the hammer piston. As the air does its work simultaneously with its compression, the usual heat losses are avoided. The line shaft, 3-inch diameter and 30 feet long with five hangers was driven by an electric motor, and an ammeter gave the means for an accurate record of the power consumption. The smallest hammer had a stroke of 12 inches and made 250 blows a minute; the second, 17 inches and 160 blows; and the third, 24 inches and 120 blows a minute.

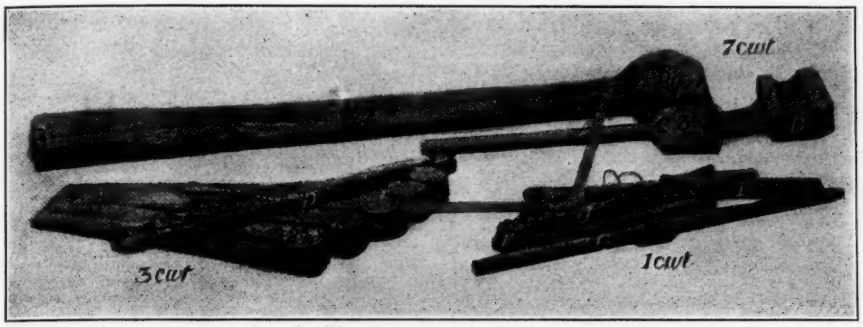


FIG. II.—SAMPLES OF WORK OF PNEUMATIC HAMMER.

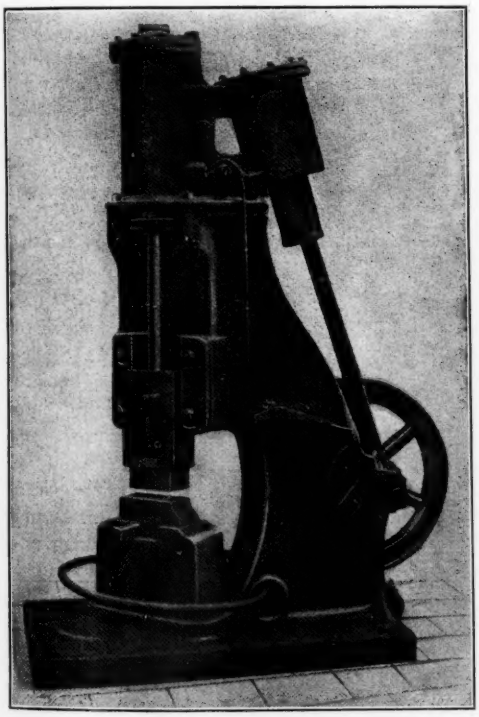


FIG. I.—PNEUMATIC POWER HAMMER.

Reference.	Job.	Size of hammer	Power, B. of T.U. (kilowatt hours) 1 cwt.	3 cwt.	7 cwt.	Total.
F	Lever		0·24			
C	Joint	(1st heat)			0·57	
D	Lever			0·66		
B	Swage	(1st heat)			0·44	
I	Tool		0·22			
D	Lever			0·34		
B	Swage	(2nd heat)			0·45	
G	Spindle	(1st heat)	0·13			
D	Lever			0·34		
B	Swage	(3rd heat)			0·45	
G	Spindle	(2nd heat)	0·24			
D	Lever			0·45		
A	Connecting-rod	(1st heat)			1·44	
E	Connecting-rod	(1st heat)	0·46			
D	Lever			0·56		
J	Joint		·41			
A	Connecting-rod	(2nd heat)			0·18	
H	Joint		0·24			
D	Lever			0·45		
Total power used in two hours by hammers (exclusive of transmission losses)			1·94	2·80	3·53	8·27
Ditto, per hour			0·97	1·4	1·76	4·13
Average power used by hammers (exclusive of transmission losses), B.H.P.			1·30	1·87	2·36	5·53
Power used in driving shaft and belts (average efficiency of motor 85 per cent.), B.H.P.						6·06
Average power for three hammers, shaft and belts, B.H.P.						11·59
Cost with engine power at id. per B.H.P. per hour, pence (or electric current at 77d. per B. of T.U., average efficiency of motor being 85 per cent.)						5·8

TABLE OF PNEUMATIC POWER HAMMER TESTS.

A number of pieces of work were chosen to be done by each hammer. These are shown in three groups in Fig. 2, and the power results of the tests are given in the table. The average power used by the hammers, exclusive of losses in transmission, was 1.30, 1.87, and 2.36

brake horse power, while the average power required to drive the three hammers, with shafting, belting and bearing friction was only 11.59 brake horse power. The highest power required, with not more than one hammer operating at once, is 24 brake horse power. The total cost of power for operating this set of hammers through shafting and belts will, of course, vary with that of the motive power, but if a gas engine be employed giving 1 brake horse power for 1 cent, a fairly liberal figure, the cost would only amount to about 12 cents per hour.

THE EAST RIVER GAS TUNNEL

The first completed tunnel under the East River, that of the East River Gas Company, for the transmission of illuminating gas from the gas works in Long Island for distribution throughout Manhattan, was of unusual interest and importance in that its successful completion demonstrated the entire possibility of constructing similar tunnels under the same waterway wherever they may be required and also that the progress of the work revealed the peculiar conditions and the special difficulties which might be expected to be encountered in similar undertakings in the same neighborhood. This tunnel was not as large in section as would be required for a standard railroad, or even for trolley cars and general traffic, but it was still large enough to reveal all the difficulties which a larger construction would have involved. The rock section was required to be 8 1-2 feet high and 10 feet wide, and the heading was driven the full width. The location of the tunnel is from Webster Avenue, Ravenswood, Long Island under both channels of the East River, with Blackwell's Island between them, to Seventy-second Street, Manhattan. The roof grade of the tunnel was 40 feet below the lowest point in the bed of the river, which was in the west channel, and 111 feet below mean high water mark. The water in the east channel was not more than half so deep as that in the west channel so that the depth of ground over the tunnel was there much greater.

Preliminary investigation revealed bed rock on both sides of the river only a few feet below the surface and also on the island, and drill soundings made with difficulty in both channels seemed to show from two to five feet of sand and gravel at the bottom and then solid rock, so that the driving of the tunnel was expected to be a clean and uninterrupted job straight through, and the contract for the job was placed on that basis.

Work was begun by the contractors, McLaughlin, Reilly & Co., at the Long Island end June 28, 1892. Bed rock was found 9 1-2 feet below the surface, a compact gueiss almost approaching granite. Work commenced on the New York end July 10. The rock here was the regular micacious gueiss known as "New York rock." The rock in the New York shaft was straight grained with dip of about 10 degrees from the vertical, striking nearly north and south and becoming harder as the depth increased. No water or any abnormal difficulties were encountered and the bottom of the shaft was reached at the end of October, 139 1-2 feet below the surface. At the Long Island shaft the progress was not as rapid. The rock was seamy and much water was encountered. There was no reliable water supply for the boilers, and the water obtainable, although not salt, was entirely unfit for use and there were numerous stoppages during the entire continuance of the work on account of the water supply.

The care and precision with which the line was laid are indicated by the fact that when the headings met, 1,678 feet from the New York shore, the lines were within 1-2 inch of each other laterally and 1 1-4 inch vertically.

Two Ingersoll-Sergeant compressors were installed at each end of the tunnel, and drills of the same company were employed throughout the work. On the New York end the driving of the heading proceeded to a distance of 348 feet when a seam of decomposed rock was struck, a straight face across the heading. After advancing into this 9 feet it was found unsafe to proceed, the ground finally having reached "about the consistency of soup." A steel air lock 6 feet diameter and 10 feet long was made and fastened solidly in the rock, and working under air pressure was commenced, the initial pressure being 35 pounds; electric lighting was installed.

The heading was enlarged and changed to a circle 12 feet in diameter. The tunnel in this part was lined as it advanced with light plates of wrought iron connected with angle

irons, and 12 inches of brick work was laid inside the plates. One half of the thickness of the brick was subsequently removed and a lining consisting of cast iron segments bolted together finished the job.

The working air pressure was ultimately raised to 48 pounds, which was higher than men had ever worked in before, and they began to experience serious difficulty in continuing the work. Four deaths in all resulted from the air pressure, and there were no other deaths or accidents in the entire progress of the work. The first man to die was a foreman. The second man had been long out of employment and was in very low condition. He died in the air lock after his first shift of two hours. The third man became paralyzed from his shoulders down and died soon after. The fourth man died nearly a year after the others.

In connection with this feature of the work the following rules for men working in compressed air were formulated by Dr. Andrew H. Smith of the Presbyterian Hospital:

Rules for Men Working in Compressed Air:

1. Never enter the air lock with an empty stomach.

2. Use as far as possible a meat diet, and take warm coffee freely.

3. Always put on extra clothing in coming out, and avoid exposure to cold.

4. Exercise as litle as may be during the first hour after coming out, and lie down if possible.

5. Use intoxicating liquors sparingly. Better not at all.

6. Take at least eight hours sleep every night.

7. See that the bowels are evacuated every day.

8. Never enter the lock if at all sick

9. In exit from the air lock, the time occupied should be five minutes for each atmosphere above the normal.

The earliest injurious effect experienced is an itching caused by air globules in the capillaries, which may be quickly cured by inducing profuse perspiration.

The "bends," a more serious trouble, is an intense rheumatic pain in the joints caused by air globules in the sockets.

Paralysis leaves lasting injury and is usually the cause of death when it occurs.

A highly steam heated dressing room was found beneficial, with copious supplies of hot, strong coffee

For pressures up to 30 pounds the men worked two shifts of four hours each, with one hour of rest between. For the highest pressure the men worked only 1 1-2 hours at a time, and 4 1-2 hours for the entire day.

The information herein contained is mostly abstracted from the report of the chief engineer, Mr. Charles M. Jacobs, Mem. Inst. C. E. Mem. Inst. M. E. The following narration of a bit of experience of Sunday, March 26, 1893, is quoted from the report. "In order to keep an exact record of the air pressure I had fitted up an Edson automatic recording pressure gauge with high and low pressure alarm bells attached. The foreman of the contractors with the engineer had broken the lock and removed the pencil. The fires were nearly out and the compressors were stopping, the pressure having fallen 11 pounds. A large quantity of soft ground had worked into the heading, entailing more exercise of ingenuity and determination to get things going right again. A great cavity had washed in and the water was bringing it down continuously."

In the progress of the work serious troubles occurred with the contractors who finally abandoned the entire contract. At one point they had to be restrained by injunction from removing their compressors at a critical time. The air pressure would not have been maintained and a general collapse might have resulted. The matter became a subject of litigation.

At the Long Island end of the work the troubles had their own individuality. Bad and insufficient water for the boilers caused frequent stoppages while it was essential to keep the pumps active to prevent drowning out. The first soft ground was met 253 feet from the shaft, and at 285 feet a green slimy and almost liquid material began oozing out, which so embarrassed the contractors that they then abandoned the work allowing the heading to fill with water.

The stringency of the money market in 1893 was another incident which caused a cessation of all operations for a couple of months.

A neighboring picnic place, "Jones's Woods," took fire and with it was destroyed the entire plant at the New York end, and before pumps and compressors could be in-

stalled the heading was drowned out again.

The time of greatest anxiety, difficulty and risk was when in advancing the shield at the New York end a shelving bank of rock was found in front of the bottom of the shield, while at the top was the softest black mud. It was necessary to blast out this rock in the floor in advance of the shield and to get through the bulkhead which had been put in when the work had been abandoned. Direct communication was opened with the river, so that refuse and even live crabs came into the tunnels. The leakage of air was so great that both compressers at the limit of their speed had difficulty in maintaining the pressure of 48 pounds. The difficulties continued until the shield was entirely entered into the black mud, when the pressure was reduced and the shield was advanced at the rate of 6 feet per day. The shield was pushed forward by twelve hydraulic jacks with a combined thrust of 600 tons. The second soft place extended 98 feet. The rock ahead was badly seamed, but finally became solid again and then in two weeks 101 feet and 94.6 feet advance respectively was made, which rate had never been surpassed in that class of rock.

The headings met July 11, 1894, 1,676 feet from the New York shaft. The total distance from shaft to shaft was 2,550 feet, so that two thirds of the length was driven from the New York end. When working in solid rock the average progress was 69 feet per week. Bonuses were given to foremen and to some of the gang leaders.

Considering the unexpected difficulties encountered and the delays from so many different causes the total time from the beginning to the completion of the tunnel, a few days over two years, must be considered remarkable, and could only have been possible with constant resourcefulness and untiring push. After the ends met there was little more to be done and in a very short time a 36 inch gas main was laid with an uninterrupted motor car track at the side of it.

The best preventive of the spontaneous ignition of coal is a small cylinder of compressed carbon dioxide fitted with a fuse plug melting at 200°F. A cylinder 1 ft. long and 3 in. diam. would be sufficient to fill the pores of 8 tons of coal.

ARTESIAN WELL PUMPING BY COMPRESSED AIR

By H. Tipper, M. E.

The economics of artesian well pumping is, particularly to the people of the Southwest, an important question. There is only a small amount of surface water in that district and of that none can be used safely without thorough purification. Artesian water can be obtained with ease, in a great majority of cases, and while it may contain permanent and temporary hardness, it is free from all dangerous contamination.

Engineers, independently of the large manufacturers of compressed air apparatus, know very little about lifting water by air, and the writer has observed case after case where this has been the cause of disastrous and costly experiments, both in private and city plants.

The proper proportion of air and water pipes, the proper submergence, the condition of the casing, and the style of lift used are points which appear to receive vastly too little attention from the people in charge, with the result that the practice of using compressed air gets saddled with faults not of its making.

The assumption that an air-lift system is getting the best efficiency of a well because the water is being delivered and there is no apparent defect is responsible for the absence of any general reliable data from independent sources on this subject, at least so far as it pertained to the Southwest, and it is to state the conditions in this territory, as found by the writer, that this article is written.

The sands from which the artesian water is secured in the State of Texas vary largely in their textures, their static head and the depth at which they are found. Thus, at El Paso there are four or five water-bearing strata within 300 ft. of the surface, and the static head from any of these comparatively small. North Texas is supplied from the Trinity sands and from the Paluxy sands. Of these sands the Trinity sands are the greatest and most important. Borings have been made and artesian water supplied from these sands in the larger part of Texas, including Fort Worth, Dallas, Waco, Austin and San Antonio. The Trinity sands are

generally a white quartz, but vary greatly in texture, in different portions of the strata.

In addition to the cities named, a number of smaller towns, and a larger number of private plants, take their water from the Trinity strata.

In Forth Worth the depth of the sand from the surface is about 1,000 ft. and the static head about 900 ft.; in Dallas the depth is almost 2,000 ft., and wells have flowed there with 100-ft. head pressure.

In Waco the wells all flow, though not sufficiently to be able to supply the town without pumping. All along these sands the conditions are good for artesian pumping with compressed air. In the first place the lift is not more than 150 ft. The submergence can be placed at the most economical point, and the water which is secured is of excellent quality.

It has been necessary for the writer in the course of business to investigate the condition of numbers of wells, and in very few cases, so few as to be hardly worth considering, have the wells been in a condition which would make economic pumping possible. The chief difficulties found are:

(1) Bad casings. In a large majority of cases the wells have been shot with dynamite at the least suspicion of not delivering the required amount of water. Frequently this has been done carelessly and in such a manner as to irreparably damage the casing, and allow the air to escape into the surrounding strata instead of being engaged in lifting the water. In many instances the casing had been allowed to rust and become perforated with holes so that it was of no value for use with an air-lift. There seemed to be little or no attempt to keep the casing in good condition.

(2) Badly proportioned air and discharge pipes, and poor arrangements of pipes. The use of air pipes of altogether too small diameter is common. This causes a frictional resistance of a very expensive character. There may also be noted an absence of any attempt at proportioning the discharge pipe so as to get the most economical delivery of water from the well.

(3) The choking of well with the remains of rotted pipes and former attempts at pumping. It is surprising how often this occurs.

(4) The absence of any tests, or any means of ascertaining comparatively the performance of an air-lift at one date with another.

It is absolutely amazing how much in the dark the people using artesian water frequently are as to the amount received. Even in large cities like Fort Worth and Waco there are no records of tests made on the wells to ascertain the amount of water received or the cost of obtaining it.

The cost of obtaining water from the artesian strata by air-lift varies with the lift and submergence, but in the average a great deal of the cost is due to neglect. In my investigations of the subject I have found that the efficiency of the air-lift in moving water from the same strata practically through the same lift and under similar conditions runs all the way from 5 to 25 per cent.

The cost of delivering the water, depends in the first case on the compressor, and the great difference in compressors allows of some consideration of that subject.

The volumetric efficiency of the air cylinder of a 250-cu.-ft. compressor ought to reach 85 per cent., yet I have found that badly constructed valves and long narrow heated ports have reduced this to 40 per cent. in several cases.

The intake valves of the compressor should be a large part of the cylinder area, they should be placed and posted so that the rise in temperature of the air before it reaches the cylinder will be a minimum. They should, if possible, provide against any chance of irregular wear. The discharge valves should leave as little as possible of clearance, so as to keep the volumetric efficiency high and should be kept away from the intake valves.

It cannot be regarded as good construction for the intake and discharge valves to use the same ports: as the passage of the heated air, when discharged, over the metal over which the intake air must afterwards pass, results in the heating and expansion of the incoming air unnecessarily and consequent loss of efficiency.

The state in which compressors are allowed to run is one of the marvels which keep an engineer guessing. While the steam engines of the plants receive the best attention, too often the compressor must take care of itself, and it is to be regarded as to the credit of compressor manufactur-

ers that they stand the strain so well. I have seen compressors running with the intake pipes open not 6 ft. from a boiler furnace, absorbing all the dust from the boiler front and running it into the cylinder to the detriment of valves, cylinder and all other parts around the cylinder. In the same place was being used, in the air cylinder, a thick black steam cylinder oil, and the thick oil and dust must have formed an excellent grinding material round the piston.

The next question relates to the piping of the well, and here a great deal of damage is done and a great deal of unnecessary expenditure incurred. I counted in four weeks, in this territory, over 25 cases where air lines of 1 in. had been used to supply air for 6-in. wells, with the inside air-line system. The average length of the pipe was 350 ft. from the well top; and often it was another 300 ft. to the compressor. Figure out the frictional loss occasioned by this, and the additional load thrown on compressor by the loss. These wells were pumping an average of 75 gals. per min. and using a compressor delivering 200 cu. ft. for the work, with a net efficiency of about 6½ per cent. After altering one of these pipes to a 2½-in. pipe above the well, putting in a receiver storage at the discharge of the compressor, and putting a 2-in. pipe down in the well, the average delivery reached 180 gals. per min. with the use of a little less than 200 cu. ft. of free air, the efficiency in this case being about 23 per cent.

In another case I found two wells of different depths, worked by different pressures, being fed from the same pipe, with of course the absolute loss of one well.

In experimenting with the matter I have found that a large receiver capacity, and a large pipe above ground, a 55 per cent. submergence and a frictional loss of not more than 5 per cent. allowed for in the piping proportions in the well bring the best results. With these and a lift of not more than 200 ft. I have been able to get an average of at least 1 gal. of water per cu. ft. of air per min.

The use of long lines of discharge pipe from the well horizontally, instead of allowing the well to discharge into a basin and the water to flow thence by gravity or be pumped by separate pumps to its required place, have a bad effect on the efficiency of the air-lift and should never be used. The most efficient scheme is a straight lift either to surface or elevated tanks, all long horizontal work to be taken care of by separate pumping system.

The ultimate economy of the air-lift as compared with pumping jacks, or with deep-well pumps, whether steam or electrically-driven, depends not at all on the efficiency, as, percentage for percentage, it is the most expensive system of pumping. Its utmost efficiency is not more than 25 per cent. to 30 per cent., while that of deep-well pumps, especially of the double-acting type, runs very much higher. The economy in the air-lift lies in its power of supplying a much greater quantity of water from the same sized well than the deep-well pumps, except in cases of low submergence, when it is useless to install the air-lift.

Not being limited to a certain displacement capacity, the quantity of water that can be raised by the air-lift is limited only to the amount possible for that sized pipe to carry at the velocity reached from the pressure of air employed. There is also economy in the absence of working parts down in the well and in saving frequent repairing to these with great loss of time and money. Properly installed and properly attended to, the air-lift system of delivering artesian water, while mechanically inefficient, represents the least troublesome, most desirable and most easily looked after system of obtaining the water under these circumstances at present in use.—*Engineering News.*

THE WEG BREATHING APPARATUS

The mechanical drawing, here reproduced from the *Engineering and Mining Journal* of a man equipped with a breathing apparatus for use in rescue work where the air has been rendered unbreathable by fire or explosion, has a decidedly steam boiler effect. There is, however, no boiler plate about it, the entire apparatus weighing only about 30 lbs., and being worn or carried without discomfort.

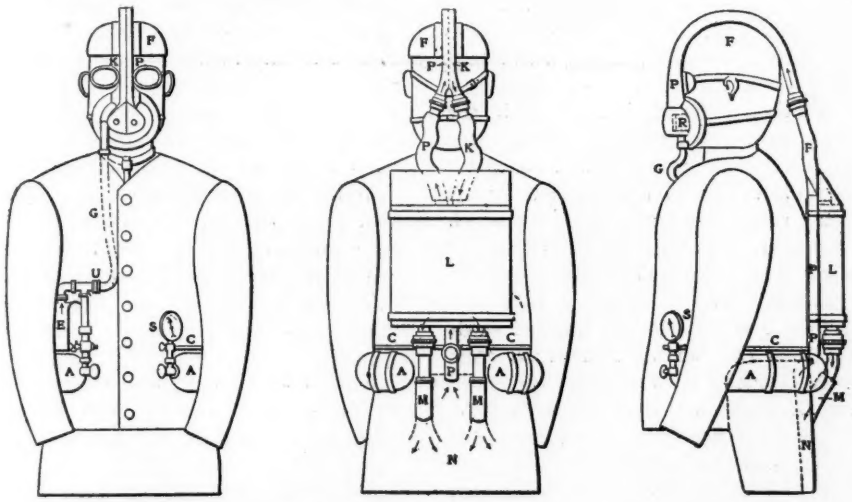
The wearer breathes into and out of a bag which is provided with such arrangements that the carbon dioxide is absorbed and oxygen is supplied from a steel cylinder to replace that which is used up, the supply of oxygen being regulated automatically with the consumption. The cap *F* fits the head

of the wearer, and each cap has to be fitted to the individual head. It is not in the nature of a diver's helmet. The fact of its fitting this way provides, as it were, a safety valve in case the pressure inside should for any reason become too great. The oxygen cylinders are shown at *A*. The negative pressure of inhalation draws oxygen through the special regulator *E* and up the pipes *C* into the pipe *P*. The air expired by the wearer passes down the pipe *K* to the potash purifier *L* on the back, and after having its carbonic oxide removed, passes through the pipes *M* into the breathing bag *N* below. From this breathing bag the air is drawn up through the pipe *P*, where it is revived by the admission of oxygen as described. Valves are arranged at various points so that this circulation of the air is properly maintained. There is a pressure gage at *S*, and a direct pipe *G* which in case of emergency can be used to supply oxygen direct to the mouthpiece. The cylinders contain 150 liters (5 cu. ft.) of oxygen at the atmospheric pressure, and the consumption varies from ⅓ to 1⅔ liters (20 to 100 cu. in.) per minute.

The apparatus takes its name from the initials of its designer, Mr. W. E. Gorfarth, and is in use in the Altafts colleries, Yorkshire. Various tests have been made of it by the Royal Commission, in the experimental gallery filled with unbreathable smoke.

In the first test the subject worked very hard for two hours, lifting weights chiefly, the total work being 77,000 ft. lb. The analyses showed that the absorption of carbonic acid was good, and the constantly rising percentage of oxygen indicated that the apparatus was being washed out all the time. The consumption of oxygen was only 1¼ liters per minute.

The second test commenced with a period of rest extending over an hour and a half. The subject then used less than ⅓ of a liter of oxygen per minute. Afterward an hour and a quarter's hard work was done, during which the measured work was 92,000 ft. lb. The consumption of oxygen rose to 0.7 liter per minute. In the third test there were five men at work for 1¼ hours extinguishing fires, putting up screens, and carrying stretchers. The average consumption during this test was as high as 1.6 liters per man per minute.



THE WEG RESCUE APPARATUS.

A bill has been introduced in the British Parliament "to promote the earlier use of daylight in certain months of the year. The scheme is to advance the clock 20 minutes on each of the four Sundays of April. It is stated that the saving of daylight in the six summer months would amount to about 700 hours, and by going to work earlier the artisan would acquire command of long afternoons for recreation or study. The saving in artificial light is figured at $10,000,000 per year.

PINTSCH GAS AND CARBURETTED AIR SYSTEMS OF CAR LIGHTING

The following we take from a paper on "Car Lighting" by Mr. R. M. Dixon, President of The Safety Car Heating and Lighting Company, presented at the meeting, Jan. 14, of the American Society of Mechanical Engineers.

The Pintsch compressed gas system has been found to meet the requirements of the railroads of the world to an extent covering probably 80 per cent. of the passenger cars in service, notwithstanding the fact that the Pintsch system is absolutely dependent for its light upon stationary supply plants. It is the most extensively used system of car lighting, and notwithstanding the number of cars now lighted by other methods, it is an unquestionable fact that more cars are lighted by the Pintsch system of lighting than with any other light at any time. The gas is produced by the fractional distillation of petroleum oil and the apparatus is especially arranged to produce gas which will lose a minimum amount of its illuminating value in the compression to which it is afterward subjected, namely, about 200 pounds per square inch. It is stored at the plants under this pressure in vessels which are connected by pipe lines to the railroad yards to which it is charged by equalization from 150 to 180 pounds into the tanks suspended from the floor framing of the cars. At the present time there are seventy of these plants established; their distributing systems being connected with about 350 railroad terminals, thus enabling managements of railroads to apply gas lighting to cars without expense for gas supply plants.

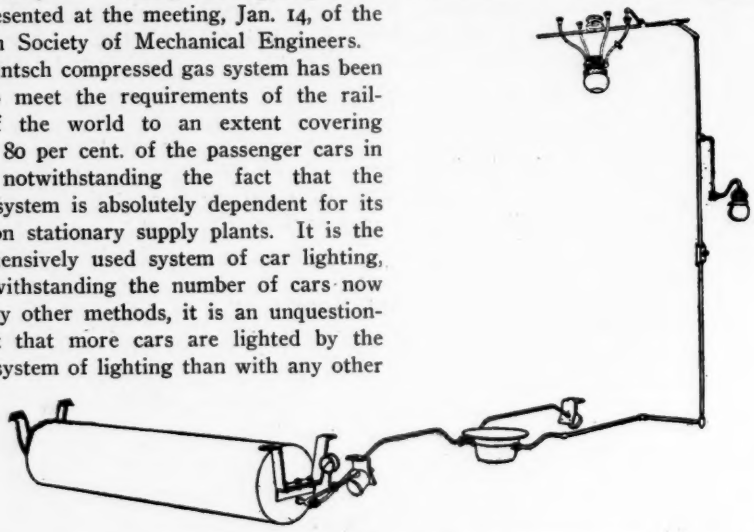


FIG. I.—PINTSCH GAS EQUIPMENT USING MANTLE LAMPS.

The gas furnished is measured by the increased pressure in atmospheres times the volume of the tanks on cars in cubic feet the railroad company paying for the net amount of gas supplied to the tanks. Car tanks are of welded steel, 21 inches in diameter and either 8 feet 6 inches or 9 feet 6 inches long, the shorter holder contains 19 cubic feet per atmosphere and the longer one 21.18 cubic feet per atmosphere. In many instances more than one tank is applied to a car. The normal charging pressure is 10 atmospheres. There is a filling valve on each side of the car for convenience in filling, and a gage located near the tank underneath the car indicating the initial and final pressures. See. Fig. 1. The high pressure piping system consists of a ¼ inch extra heavy wrought iron pipe extending across the floor of the car to the filling valves with a branch to each tank and a short branch to the reducing valve or pressure regulator, located underneath the car near the tank. From the pressure regulator a ½ inch standard wrought iron pipe conveys the gas underneath the floor at some convenient point and then to the roof where a distributing pipe extends on the outside with branches to each lamp.

Until recently the gas has been burned in standard four flame lamps of various designs finished to harmonize with the interior construction and ornamentation of the cars. The aggregate consumption of the four flame lamp is about three cubic feet an hour and the illumination about thirty-three candles light. About three years ago, by the development of an inverted mantle which is sufficiently substantial for railway service, it became possible to get 90 candles light from the same consumption of gas, that is, three cubic feet per hour. This required the use of a cluster of four

mantles but still more recently a mantle has been developed which, with a consumption of two and one-eighth cubic foot per hour, gives from 95 to 100 candles light, or per cubic feet of gas nearly fifty candles. At the standard selling price of the gas the cost of operation of these lamps is but one and one-sixteenth cents an hour.

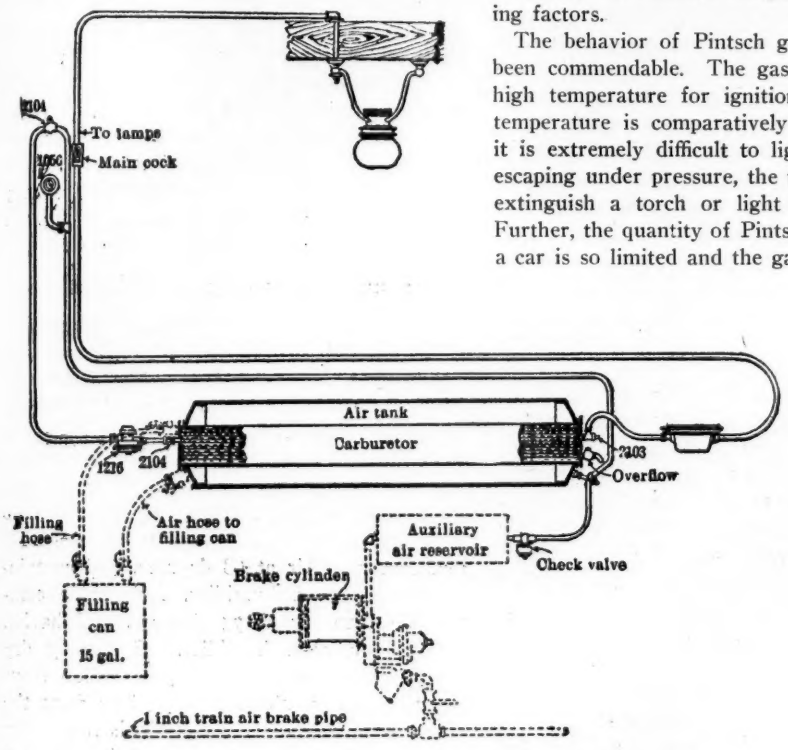


FIG. 11.—INCANDESCENT VAPOR CAR LIGHTING.

Mantle lamps are giving great satisfaction to the railroad managers. More than three thousand cars in America are now equipped with them and they are securing quite a general adoption in Europe. The Prussian State Railway Administration has contracted for about thirty-eight hundred new cars fitted with mantles, and for the change of their present equipment before the end of the year 1909. In France more than 10,000 cars are equipped and on order. Pintsch equipment has been applied to more than 160,000 cars, aggregating more than 1,000,000 center lamps and more than 400,000 tanks: 33,000 cars have been equipped in North America and the entire equipment is available for use with an expense of but $100 or $125 per car, thereby increasing the light three fold and reducing the consumption of gas 30 per cent., increasing the carrying capacity of the tanks and the capacity of the established gas plants about 40 per cent., thus more than trebling the value of the equipments owned by the railroad companies as light giving factors.

The behavior of Pintsch gas in wrecks has been commendable. The gas itself requires a high temperature for ignition, and the flame temperature is comparatively low. Moreover, it is extremely difficult to light the gas when escaping under pressure, the tendency being to extinguish a torch or light brought near it. Further, the quantity of Pintsch gas carried on a car is so limited and the gas is so free from vapor and its diffusion so rapid, that in the case of the rupture of a tank or the pipe connections, it is so quickly dissipated that an explosive mixture or a combustible condition is not readily obtainable.

For those cars which are in service and which do not reach Pintsch supply plants, a system has been developed for lighting by the use of carbureted air in connection with the incandescent mantle lamps. This system has been made possible by the mantle lamp development for railroad service. One disadvantage of the earlier systems was the low luminosity of air gas in cold weather. With

incandescent mantles is is possible to obtain good results with gas that is non-luminous. Another disadvantage of the old system came from the fact that a carburetor had to be placed directly over each lamp as it was impossible to have one large carburetor supply all of the lamps, owing to the collection of condensation in the pipes from a fall in temperature.

If the gas be non-luminous in quality, no condensation in the piping can take place at ordinarily low temperatures. In this new system the gas is always of this quality. This uniformity of quality is accomplished by varying the pressure under which the gas is generated in the carburetor, in accordance with the temperature, making it possible to use a carburetor of substantial construction under the car, and distributing the gas to the lamps by a piping system similar to that for cars lighted by Pintsch gas.

The operation of the system is as follows: air is taken from the auxiliary air brake reservoir, see Fig. 2, through a check valve to the air storage tank, and from this tank up to the saloon of the car where a pressure gage and shut off valve are placed. This gage shows the pressure of air in the air storage tank. From the saloon the air passes to the high pressure regulator which delivers a pressure on the carburetor in accordance with the temperature. In passing through the carburetor the air takes up sufficient gasolene vapor to make the proper gas. From the carburetor the gas passes through a low pressure regulator which reduces the pressure to that suitable for burning in the lamps. The lamps are similar in design to those used for Pintsch gas, and use the same mantle. The carburetor is contained within the air storage tank and is formed by a 12 inch pipe through the center of a steel holder 21 inches in diameter. The ends of the pipe are brazed to the heads of the holder and closed by iron plates securely bolted on. The pipe is packed full of absorbent wicking to hold the gasolene. The air passing through this wicking takes up the proper amount of vapor to form the gas. By this construction the carburetor is well protected by the walls of the air tank.

A combined air tank and carburetor, 21 inches in diameter by 8 feet 6 inches long, has when charged, 20 gallons of gasolene and will supply five 100 candle power lamps for at least 200 hours.

AIR WASHING AND HUMIDIFYING FOR INDUSTRIAL PURPOSES*

For years it had been taken for granted that good ventilation must be obtained often at the expense of cleanliness. This is particularly noticeable in communities where soft coal is used. The necessity for properly cleansing the air which is taken into buildings has long been felt, and many have been the devices used to effect this. Prominent among them might be mentioned the use of cheese cloth screens, long bags of the same material, and coke filters. These all had the disadvantage of offering too great a resistance to the passage of the air, besides giving only crude cleansing effect. They were also unsatisfactory in that they did not affect the humidity of the air to any extent.

REGULATION OF HUMIDITY DESIRABLE.

The desirability of controlling the humidity of buildings has been well brought out in a paper by an eminent specialist, Dr. Henry Mitchell Smith, read by him before the Brooklyn Medical Society in May, 1903. In it he points out that the sensible temperature of the human body more nearly corresponds to the temperature indicated by the wet bulb of a hygrophant, rather than to the dry bulb temperature. Air at 68 degrees, and containing 50 per cent. humidity, feels more comfortable than air at 75 degrees, and having but 20 per cent. humidity. Extremely dry air produces a more rapid evaporation from the mucuous membranes as well as from the entire surface of one's body. This causes the lower sensible temperature and, in the case of the former, has an unhealthful effect.

It is just this condition which is obtained where external air at a low temperature is heated to the temperature usually found in warmed buildings. If we take outside winter air at 30 degrees F. and 80 per cent. saturation, we find it contains 1.5 grains of moisture to the cubic foot. If its temperature is raised to 70 degrees without adding any moisture to it, we find that its per cent. of saturation is but 19.5, because of the fact that air at 70 degrees can absorb 8 grains of moisture. We can thus see that not only

*A paper (somewhat abridged) read before the Ohio Society of Mechanical, Electrical and Steam Engineers, by W. A. Rowe.

is it desirable to humidify the air, but also to regulate the degree of humidity.

THE WATER SPRAY.

These considerations all lead to the use of a water spray by which to cleanse and humidify at the same time. There are various essential features which must be incorporated in the design of such an apparatus to make it successful, not only from a theoretical point of view, but also from the practical or commercial standpoint. In discussing these features the writer will describe one apparatus in particular which, by reason of its having met all the requirements successfully, has enabled its manufacturer to realize certain results of great commercial importance.

INTIMATE CONTACT BETWEEN AIR AND WATER.

The first requisite of a successful washer is an intimate contact between the air and the water. The more finely the water can be divided the greater will be the contact surface and, consequently, the greater the degree of success realized. Hence a finely divided mist is essential. An ingenious nozzle has been devised with which an almost invisible finely divided spray is obtained with a pressure of but 20 pounds per square inch. In this nozzle the outlet orifice is but 3-32 inch in diameter, yet it will deliver 3.5 pounds of water per minute. The result is obtained by giving the water a centrifugal motion which causes it to burst into spray. It is easily accessible for cleansing and is of the utmost simplicity.

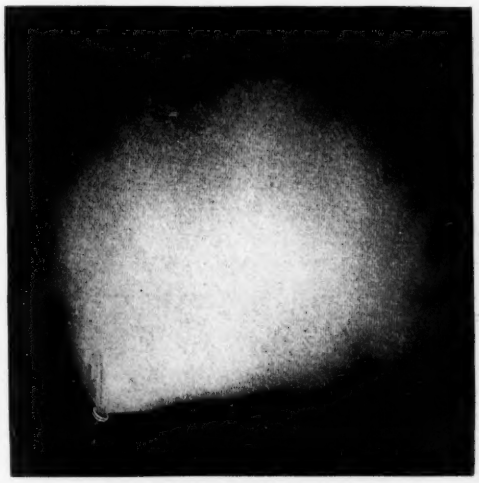
In the complete air washer these nozzles are spaced two to the square foot of cross-section area, a velocity of from 400 to 450 feet per minute through the washer being maintained. Thus where 42,000 cubic feet of air per minute is to be handled a cross-section area of 93.5 square feet, with 188 nozzles, is provided.

SEPARATION FROM AIR OF EXCESS MOISTURE.

The second important feature to be secured is thorough separation of the excess free moisture which is carried along by the air current. This is done by a series of galvanized plates placed ⅞ inch apart and containing bends 2 inches in length. There are usually six sections, the first three allowing a film of running water to completely cover them. The last three have slight projections which completely separate all traces of free moisture from the air. This eliminator thus presents a large washing surface upon which every particle of foreign matter will impinge. The construction gives 11½ square feet of washing surface for every square foot of cross-section area of the washer. The lack of resistance of this arrangement has been proved by the results of tests which show that never more than 0.1 inch water gage is ever caused by the whole washer.

CONTROL OF HUMIDITY.

The proper control of the humidity is a third requisite equally important with those already named. This is accomplished by controlling the temperature of the air in the spray chamber, and taking advantage of the law that air at any given temperature has a definite moisture absorbing capacity, this amount increasing as the temperature is raised. For example, air at 50 degrees and 70 degrees F. can absorb 4 and 8 grains of moisture, respectively, per cubic foot, at which points it becomes saturated. If it is



ATOMIZING JET.

desired to maintain 50 per cent. humidity at 70 degrees in a building, it is only necessary that the air in the spray chamber be saturated at a temperature of 50 degrees, and then afterwards raised in temperature to that of the room, without the addition of any more moisture. In this way any desired humidity can be maintained. The best results are obtained by dispensing with tempering coils entirely, depending on heated spray water to bring the temperature of the air up

to the desired point. This circulating water can be heated in any type of heater, its temperature being controlled automatically by means of a thermostat in the spray chamber.

REQUIREMENT OF DESIGN AND USUAL EQUIPMENT.

The last point and by no means the least, is that the apparatus must be free from all necessity for constant personal attention. It must be easily accessible, the nozzles easily cleaned, if such necessity should arise, and ample provision should be made for keeping foreign matter out of the circulating water.

Usually a motor driven centrifugal pump is used, the water collecting in a settling tank at the base of the washer and being recirculated. The water level in the tank is kept constant by means of a ball float and valve which replenishes that absorbed by the air in passing through. A large brass screen of 1-32 inch mesh is usually placed across the settling tank through which the water must flow before reaching the foot valve of the pump. A specially designed strainer is also placed in the discharge pump as an extra precaution. It is found that even in the dirtiest places the apparatus can run for one week end to the other, the only care being the oiling of the pump and motor bearings. Usually the settling tank is flushed out once a week and entirely new water provided. In the case of the air washer previously mentioned, having a capacity of 42,000 cubic feet of air per minute, a 2-inch centrifugal pump is used and operated by a 3-horsepower motor, circulating approximately 90 gallons of water per minute.

It is often desirable to place a distributing plate in front of the washer in order to thoroughly distribute the current of air throughout the washer. This can easily be done by means of a galvanized iron partition in which holes are punched to the extent of about 50 per cent. of the free area through the washer, the slight resistance of such a distributing plate never being over 0.05 inch water gage.

Some idea of the extent to which the cleansing effect may be carried may be obtained from recent tests made on the Carnegie Branch Library at St. Louis by Wm. H. Bryan, consulting engineer. While not going into unnecessary details it is sufficient to say that using lampblack, over 99 per cent. was removed by the washer.

CONDENSATION OF HUMIDIFIED AIR MAY BE PREVENTED.

We have already mentioned the desirability of humidity control and the means by which it is obtained. The use of hot circulating water instead of tempering coils has also been mentioned. By this means considerable saving of expense is effected and all possibility of freezing the coils is eliminated. Neither do we get sudden changes in temperature of the tempered air such as is possible where a by-pass damper or diaphragm valves are used controlled automatically by a thermostat.

Objection has been raised that excessive condensation on windows might result from humidifying the air. It has been found that this can be obviated by maintaining a temperature in the spray chamber never higher than a mean between the temperature of the external air and that of the room. For example, if we are maintaining a temperature of 70 degrees in the building, with an outside temperature of 10 degrees, a temperature of 40 degrees in the spray chamber will prevent any condensation or frosting on the windows. This is true because the glass itself is at a temperature midway between the two extremes and, therefore, is unable to lower the temperature of the air to its dew point.

HUMIDITY LOWERS TEMPERATURE OF AIR.

As a rule the fan system of heating and ventilating is only used when the outside temperature is under 60 or 65 degrees. Under these conditions an excessive humidity is absolutely impossible because of the fact that the air is raised in temperature before being brought into the room. When, however, the system is used throughout the year it often becomes desirable to get away from the high humidities quite common in warm weather. It is found that the external air can be appreciably lowered in temperature during the warm months, because the air in passing through the washer absorbs some of the moisture. The latent heat to vaporize this moisture is furnished by the air itself, hence the lowering in temperature. It is found that an absorption of from 0.8 to 0.9 grain per cubic foot gives a lowering in temperature of from 7 to 8 degrees. Greater reduction in temperature may be obtained, providing, of course, the air has not already too high a percentage of humidity.

In the greater part of our warm weather this cooling effect is not accompanied by any unpleasant humidity. Where, however, this slight increase would cause inconvenience it is possible to produce a cleansing effect without appreciable absorption of moisture, with its consequent cooling effect, by merely flooding the eliminator plates and dispensing with the fine spray. Where exceptionally high humidities are encountered, it is possible to substitute a solution of calcium chloride, 28 degrees Baumé. This solution will thoroughly wash the air without a particle being evaporated. It neither gives up nor will it absorb moisture.

In a recent test of the Carnegie Library installation, about which we have previously spoken, with an outside temperature of 86 degrees and 40 per cent. humidity, an average temperature was maintained inside the building of 77.5 degrees with 70 per cent. humidity, this being an average temperature decrease of 8.5 degrees. It was found that a lower temperature was maintained in the rooms where the windows were kept shut.

EXTRACTING MOISTURE FROM AIR.

So far we have touched only on the humidifying or adding of moisture to the air. In some branches of industrial work it is necessary to extract the moisture from air or to dehumidify it. This is particularly true in the case of drying many substances which cannot stand a high temperature. Among these might be mentioned gelatine and glue products, photographic paper, rubber, sulphur, matches, etc.

Where the material to be dried can stand the maximum probable temperature that we are likely to encounter in summer weather, say 90 degrees, we can get sufficiently dry air at any time by the use of calcium chloride solution, 40 degrees Baumé, in the air washer. This solution will extract moisture from the air, the amount depending on the strength of the solution. It is not necessary to use outside air in this instance. The air from the drying room can be returned to the washer, where it is relieved of a portion of its moisture. This chemical extraction of the moisture from the air liberates the heat of vaporization, which results in raising the temperature of the air itself. This warmer and dryer air is then returned to the drying room where it absorbs additional moisture from the material being dried. Of course the calcium chloride solution is being continually weakened while this cycle is progressing. It is necessary to use an automatically controlled evaporator to which the solution is returned where it is reconcentrated.

A more simple solution of this problem can be secured where a sufficient supply of cold water is available. With a temperature of water of 50 to 55 degrees, it is possible to reduce the temperature of the air to 58 to 63 degrees, leaving but 5.5 to 6.5 grains of moisture per cubic foot in the air. By then reheating this air to 80 to 85 degrees, we would have a 50 per cent. saturation, in which condition the air will readily absorb moisture. The large amount of cooling water necessary makes this plan too expensive in many localities, in which event the calcium chloride solution can be used, entailing small expense.

LOW TEMPERATURE DRYING.

Again, we have materials, such as photographic paper, which must be dried at a relatively low temperature all the year round. A temperature not exceeding 57 degrees F. is necessary or desirable. In cases like this no external air whatever is used except in cold weather. The air from the drying room is recirculated through the washer, in which the circulating water is cooled by refrigeration. The lowering of the temperature of the air condenses the excess moisture in it. In a recent installation this water entered the spray chamber at about 35 degrees. The air was reduced in temperature to 45 degrees, at which temperature it contains 3.4 grains per cubic foot at saturation. The air is then reheated to approximately 59 degrees when its percentage of humidity is 60. It is then returned to the drying room and the cycle repeated.

In connection with this last process it might be mentioned that a high degree of economy results from the fact that a back pressure of 45 pounds may be carried on the refrigerating machine whereas 15 pounds is usually figured for ordinary refrigeration. We also have a maximum of efficiency in the transfer of heat or cold between the water and the air, because of the intimate contact between the two. When we realize the condition that usually obtains in refrigeration work, with the frost covering pipes and cutting down the efficiency of the conducting material, the importance of this feature can be realized.

APPLICATION OF AIR WASHER AND HUMIDIFIER TO TEXTILE MILLS.

We have mentioned the application of the air washer and humidifier to textile mills. In plants of this nature constant and high humidity is of the greatest importance. In winter the heating of these buildings produces a dry and unfavorable condition. In summer the dry, hot weather, accentuated by the great amount of heat given off by the machinery, gives likewise an extremely dry and unfavorable condition in the mill. This extreme dryness prohibits the spinning of fine yarns, as well as necessitates a lower speed of the machinery, so that some artificial means to counteract those conditions is very necessary. The ideal conditions for a textile mill are indicated somewhat in the following table:

TABLE I. IDEAL CONDITIONS OF TEMPERATURE AND HUMIDITY.

Departments.	Temperature Degrees F.	Humidity Per Cent.
Spinning Room	75-80	60-75
Card Room	70-75	60-65
Winding Room	70-	75-80

It is seen that to obtain these conditions it is necessary to humidify in cold weather, and to cool in hot weather. The methods of humidifying we have already indicated in our paper, namely, by the use of circulating hot water in the spray chamber, controlling the same automatically by means of a thermostat. As a rule a large portion of the air in the mill is recirculated, only a small portion being taken from out of doors. In this way it is not necessary to add a great deal of moisture to the air after it is once at a suitable degree of saturation.

The problem of cooling in summer is perhaps more difficult than maintaining the high humidity in winter. It is possible to counteract the heat given off by the machinery in three ways, namely:

(a) Radiation—natural.
(b) Ventilation—natural or artificial.
(c) Evaporation—artificial.

While the greater portion of this heat is taken care of during the winter season by radiation, due to the difference in temperature between the room and the external air, in summer time it is necessary to take care of it by means of ventilation. To do this rapid air changes are maintained of from 5 to 6 minutes in the mill, the air being lowered in temperature by the absorption of moisture in the spray chamber, as we have previously mentioned.

It might be of interest to know that recently, with recirculated water in the washer, and by opposing the spray nozzles to the direction of the flow of the air, the air was cooled from 81 degrees down to 65 degrees. Of course this lowering in temperature is caused by the absorption of moisture tending to bring the air pretty nearly to the point of saturation. This cooled, humid air is then discharged into the mill where it is slightly raised in temperature, both by heat liberated from the machinery, and by the radiation through the walls, because of the higher external temperature.

With this system it is possible to keep all the windows in the mill closed. In fact, better results are obtained in that way. It is thus possible to eliminate the trouble experienced by draughts of air blowing in and breaking the fine yarns and causing endless trouble. By doing away with the old-fashioned method of having water dripping around the walls it is possible to entirely eliminate all free moisture from the air with its attendant rusting of machinery.

The following three tests will give some idea as to the closeness with which the ideal conditions can be approximated at varying outside temperatures. Two of these mills were located in North Carolina, while the third is in Hamilton, Ontario.

TABLE II. TEMPERATURE AND HUMIDITY TESTS.

Location.	Test No. 1. Temperature, Degrees F.	Test No. 1. Humidity, Per Cent.	Test No. 2. Temperature, Degrees F.	Test No. 2. Humidity, Per Cent.	Test No. 3. Temperature, Degrees F.	Test No. 3. Humidity, Per Cent.
Outside	51	31	48	95	34	62
Card Room ..	71	61	73	64	74	60
Spinning Room	80	70	79	70	79	66
Winding Room	70	83	71	86	—	—

Some idea as to the length of time this apparatus can be operated without any great personal attention is shown from the fact that after 2 weeks' continuous running, with a large portion of the air recirculated, but one nozzle out of 280 was clogged. When we think of the lint and foreign matter which is present in textile mills, it seems remarkable that such good results can be obtained.

B. T. U INSTEAD OF CANDLE POWER FOR GAS STANDARDS

The ordinace defining the quality of the gas furnished by the Dallas Gas Company, Dallas, Texas, provides that the gas "shall be a merchantable illuminating gas, as free of impurities, and as uniform in composition as is possible to be made, and of such quality that one cubic foot of the city gas, at 77 degrees Fahrenheit and 716 millimeters of mercury pressure, shall contain 650 British thermal units."

The reasons for the adoption of the heating rather than the lighting standard for gas are stated by Mr. J. C. Chisholm who investigated the subject and reported to the city officials. He says:

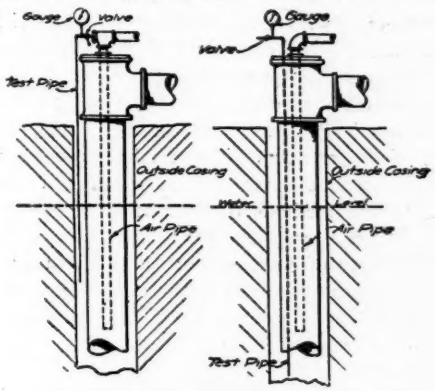
1. Candle power standards were necessary when gas was first manufactured and burned in fish-tail or jet burners; the olefines producing the light, which is therefore proportional to the percentage of these gases. The very extensive use of Welsbach lamps, however, has made it desirable to base the efficiency of the gas upon its heating power, since in these the light is given by the heating of the mantle to incandescence, wherefore heating power rather than direct light given is what is desired in modern gas. Moreover, 90 per cent. of the gas at Dallas is used for fuel purposes, for which light-giving properties are considered as of no value, and consequently heat units form the natural bases for measurement.

2. It is possible, by using producer gas or semi-water gas, to make a gas that may be 18 to 22 candle power and yet contain not more than 450 to 550 British thermal units. Coal gas, carbureted water gas and oil gas, as manufactured by the majority of our cities, contain 650 to 680 British thermal units; furthermore, it is impossible to economically manufacture a gas containg 650 British thermal units without requiring sufficient carbureting material to produce a gas of 18 to 22 or more candle power.

3. The ordinance also requires the price of 1,000 cubic feet to be prorated, if the number of British thermal units fall below 650 for a month's average.

COMPRESSED AIR FOR MEASURING DEPTH OF WATER

In a paper by Mr. Charles B. Burdick, before the Western Society of Engineers, the device shown in the sketch is described and is said to have been in use ten years or more. There is simply a small pipe say ¼ inch, and a pressure gage reading to single pounds or



FOR MEASURING DEPTH OF WATER.

less. A pipe of sufficient length, the length being known, is lowered into the well and air pressure is then applied until the air escapes from the lower end and consequently the pressure at the gage will rise no higher. The reading of the gage in pounds multiplied by 2.304 will give the height of the water in feet above the submerged end of the pipe. The cut shows the arrangements in connection with an air-lift. The left hand figure shows a case where the exterior of the water pipe is accessible. Upon an air-lift when this can be done the compressed air can be obtained by tapping the air pipe. The right hand figure show an application to an air-lift where there is no room outside, and with this arrangement a hand air pump is desirable, as the pressure required in the test pipe is a little in excess of that in the air pipe. The ordinary beer pump or large bicycle air pump answers this purpose nicely. Applied in this way the lift can be measured readily, even when the well casing is used as a discharge pipe.

FOR ENGINEERING EXPERIMENT STATIONS

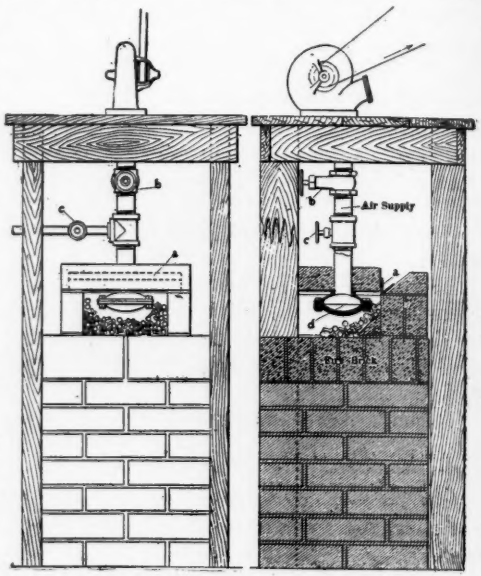
A bill has been introduced in Congress for the establishing of engineering stations, the purpose of which will be to conduct original researches or to verify experiments which relate to the properties of materials employed in manufacturing, building, and constructional operations; the properties, physical and chemical, of fuels, fluid media, lubricants, and other substances or materials used in the generation or transmission of power; the efficiency and economic value of mechanical devices; the generation, transmission, and utilization of electrical energy; the engineering problems connected with transportation; the provision of suitable water supply for domestic and manufacturing purposes; the disposition of industrial, household, and city wastes; the engineering problems connected with public utilities; the economic methods of mining and preparation of ores and other mineral products; the methods of prevention of waste of all natural resources whose use is related to the science of engineering; and such other researches or experiments bearing directly upon the application of the mechanic arts and science of engineering to the industries of the United States.

To endow and maintain these engineering experiment stations, Congress is asked to make an appropriation of $30,000 annually, to be paid to each state or territory. Out of the first five annual appropriations received by any station an aggregate amount not exceeding $30,000 may be expended in the erection, enlargment, or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding 5 per cent. of such annual appropriation may be so expended. These experiment stations may be established at any of the state schools, but unless definite action is taken by the state the privilege and appropriation would go to the land grant colleges.

It would seem that much more could be accomplished in the direction indicated by the concentration of the expenditure upon a single National institution. Better men could be employed, more systematic and comprehensive courses could be laid out and followed, more usable and accessible records could be kept, and there would be no wasting of time and effort in the simultaneous pursuit of the same lines of experiment and investigation at several stations. The expenditure which must seem quite inadequate for any state, would be a handsome and quite adequate endowment for a single plant. To spread the money as proposed would be practically to throw it away.

GAS FURNACE FOR HEATING RIVETS

The sketch shows a simple furnace for heating rivets. The setting is substantial and can be installed at a slight cost, the largest item being the small fan for the blast. The air supply for the 12-inch fan can be regu-



GAS FURNACE FOR HEATING RIVETS.

lated by means of the valve *b*. The gas enters through valve *c*, which acts as a medium of control. Air and gas combine in the lower part of the air pipe and in the burner *d*, from which it issues in a downward direction. The fire box is constructed of fire brick and has an open front, also a small opening in the rear, which is covered by the V-shaped plate marked *A* in the sketch.

The rivets are dropped through this latter opening and roll down the inclined inner rear surface of the furnace to a position under the burner. They can thus be fed in gradually; as the flame can be controlled to give the proper temperature, the rivets can be heated to the proper degree without danger of burning them, as often happens in a hand forge.

No special attendant is required to watch the rivets after the flame is once adjusted. This furnace has been in operation for some time, giving entire satisfaction.—*American Machinist.*

A LONG DRAINAGE TUNNEL

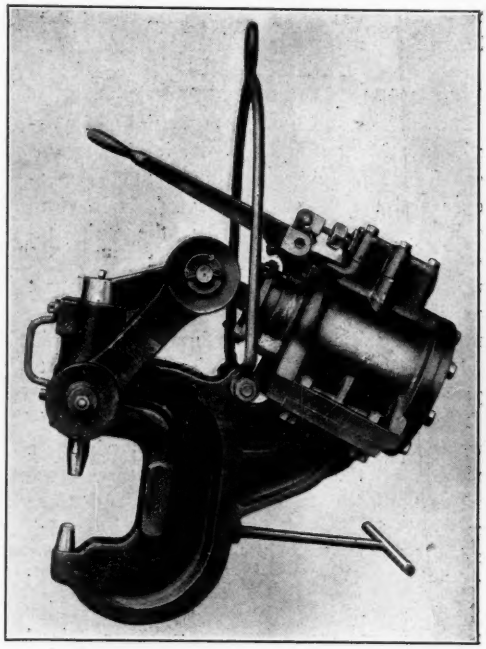
The deep drainage tunnel projected and financed by the mining corporations of the Cripple Creek district, has been driven to date approximately 1,250 feet, leaving 14,300 feet to be covered before the main water channel is tapped. The bore, destined to become the all-important factor in the great gold camp's future was formally commenced on May 11, 1907. The work, however, has not progressed as rapidly as anticipated and two contracts have been declared forfeited. Work has not even temporarily ceased, as, until a new contract shall have been let, the Cripple Creek Drainage and Tunnel Company is continuing the work. The contracting parties will be required to drive the bore 750 feet each three months, until the intermediate shaft is completed to the tunnel level, when the driving of the bore must be carried on at the rate of 1,500 feet, as the work will then be prosecuted from three distinct headings. The conditions required for the sinking of the intermediate shaft call for the sinking of 200 feet each three months. The depth of the tunnel shaft to the tunnel level is 880 feet, and 100 feet of sinking has already been accomplished.

A NEW PORTABLE PNEUMATIC COMPRESSION RIVETER

Perhaps in few lines of apparatus is the economy of the pneumatic device for the service so pronounced as in the case of the compression riveter. We need not to be reminded of the time and the cost of hand riveting; as to the pneumatic compression riveter it is very near the truth to say that it takes no time at all, inasmuch as the actual time occupied in driving any considerable number of rivets by pneumatic compression is consumed in moving the work when the riveter is stationary or in moving the riveter when the work is stationary.

The riveter here shown has a record of having driven 12,000 rivets in 10 hours. The work was on a long plate girder, and the riveter was suspended from a trolley on an overhead runway. The operator had become very expert in moving the machine from one rivet to the next, the spacing being equal, the plates of uniform thickness, the rivets all alike 3-4 inch diameter and several heater boys keeping the holes ahead of the riveter constantly full of hot rivets. The dies were replaced by cool ones at intervals during the progress of the work.

Under similar conditions another record



ALBREE PORTABLE COMPRESSION RIVETER

was made of 10,000 rivets in 10 hours time. These figures, of course, are of interest as showing what has actually been done, but the type of work should not be forgotten. On boiler work, where the rivet must be steam tight, no such record could possibly be made, as more time would be consumed not in the riveting but in securing the joints properly together in advance of the riveting. The records speak clearly, of the facility and rapidity with which the riveter as such can be manipulated and operated.

This riveter, built by the Chester B. Albree Iron Works Company, Allegheny, Pa., has a 6-inch reach, will drive a 7-8 inch rivet and weighs 850 pounds. The rivet compression is effected not by the direct pressure of

the air but by the action of levers which give much greater force when the final squeeze occurs, thus enabling a small cylinder to be as effective as a much larger one would be under the primitive arrangement and securing the best economy in the use of the air. When desired this machine may be equipped with the maker's universal bail which will hold it suspended and in perfect balance in any position. The use of portable riveters is being rapidly extended and is promoted by the putting out of such apparatus as here shown.

A COMBINATION POWER PLANT

The various and novel combinations of power generating and power utilizing apparatus, now frequent, illustrate at once the independence and the resourcefulness of the modern engineer. At Pittsfield, Mass., the main station of the electric company is a coal burning, steam driven plant not strikingly different from many others of the present day. An outlying auxiliary station, however, is built and operated upon such different lines as to appear to be hardly of the same family.

The building, to begin with, is up-to-date, in that it is built of concrete blocks made by a machine on the spot. There are three 6,000 gallon tanks outside the building, and these are filled with fuel oil from railroad cars which run alongside. The oil is allowed to flow by gravity into the basement and then is pumped as required to two small tanks in the engine room. Here are two three-cylinder Diesel oil engines, having a common shaft with a 350 kilowatt alternator on the middle of it.

The Diesel engines are four cycle, but in other respects have special characteristics of operation. For each cycle a full charge of air is compressed to above the igniting point of the fuel, which is injected in quantities graduated according to the varying power requirements, and is burned, not exploded, under controlled conditions of temperature and pressure. The cylinders are 16 x 24 inch and each engine is rated at 225 horse power. Connected with each engine is a three-stage belt driven air compressor which delivers the air at a pressure of 1,000 pounds. This air is used not only continuously when the engines are running, but its pressure is also available for starting the engines and getting them up to speed before the oil combustion cycle is established. With each engine there are six air bottles, two of which are connected constantly with the air pipes as additions to their capacity to minimize the fluctuations when the engines are running, the other four bottles being kept charged to be always ready for starting. A motor-driven triplex pump is another element of the active service, thus using water from a neighboring lake and circulating it through the jackets of the air compressors and especially of the engine cylinders.

USE AND ABUSE OF HOT AIR

The following is a portion of a talk by Mr. C. A. Burgess at the recent annual convention at Toledo of the Ohio State Stone Club:

You all well know we have been preaching to you for years against the habit of compressing hot air. It is quite as bad as listening to it. Hot air should never be compressed, for it is a costly practice. You lose at both ends of the line by compressing hot air, you do not get the full efficiency of the compressor nor of the machinery driven by the air after the compression. Hot air is all right in its place, but its place is not in a compressor room for compressor purposes.

Hot air is an excellent embellishment in conventions and banquets. It is also an excellent tonic to use next morning in the Turkish bath after attending the conventions and banquets. How much we appreciate those heat waves the morning after, when we find ourselves chanting that little poem:

Heads of great men all remind us
If we go the proper gait
We may get up in the morning
With a head that's just as great.

We know that that "greater" effect is produced by an "after" effect and that invariably the "after" effect was produced by our separating ourselves from a generous portion of our personal effects.

While I do not believe the report, yet I have heard of instances where generous portions of hot air have been used by the quarrymen and road-builders in securing valuable crushed stone contracts from county commissioners, and not until they woke up and found that the county commissioners had been just as foxy and had used the same stuff in framing their contracts did the quarrymen and road-builders consider the practice a foolish one.

Did you ever attend a letting when every surrounding and every condition made you think you were at your home county fair and that everybody had patronized the toy balloon man? There would be forty-eleven contractors and quarrymen present, each with an estimate or proposition so inflated with hot air prices as to make it appear more like one of those variegated colored rubber bubbles than anything else.

It is only the frequent indulgence some contractors take in making hot-air estimates that allows us—the manufacturers—to sooner or later discover that our contract forms also contain hot-air germs. That portion of our contract forms which reads "30 days net" really means "30 days *nit*." It is then we do a little damage ourselves, and our finance department at the home office in New York goes us one better and simply raises—well, they pass it back to us in an even more heated condition. Then we pass it along in an equally hot condition to the party whose autograph decorates the rear section of the contract. Then he hands it back to us just a little hotter, and with just a little redder glow, and before we know it we are all raising little hells of our own.

Hot air is a dangerous thing to use in business deals, for it will surely burn up the bank account in time. Good, honest competition never did hurt anybody and never will hurt anybody. The only time we ever have occasion to spell the word "stung" in capital letters is when we get out our hot-air salve and attempt to use it on somebody or allow somebody to use it on us, or, worst of all, when we try to use it on ourselves.

When we expect to gain favors we are not entitled to we are certainly monkeying with the hot-air tank. When we fail to value honesty in our business transactions, both with our customers and ourselves, we have got the hot-air valve open again. When we fail to place a commercial value on our work or our products commensurate with what they are actually worth we have got the hot-air safety valve tied down.

The White Cliffs field in New South Wales, Australia, has produced opals to the value of $5,000,000. The field was discovered by hunters while endeavoring to track a wounded kangaroo.

AERONAUTICS AND THE ELECTRICAL ENGINEERS

At the meeting of the New York Electrical Society held in the Engineering Society's Building, Feb. 28, an interesting lecture was given by Mr. Augustus Post, the well known aeronaut, on "Navigating the Air." Perhaps a disproportionate volume of the address was given to the too familiar balloon, which was described with all its appurtenances in minute detail. A practical illustration of an ascension was given by the inflation of a model balloon perfect in every detail loaned by Mr. Albert C. Tridca, director of the International School of Aeronautics. Following the balloons proper came the motor driven and dirigible balloons of various types and then the heavier than air class. These were divided into aeroplanes, including kites, gliding machines with and without motor, and machines of the helicopter and ornithopter types. Of these two the former are direct lift machines, using propellers to lift them into the air while other propellers cause them to move forward, or the machine is tilted so that the lifting propellers also cause horizontal movements. Ornithopters, as the term suggests, are bird like with flopping wings which have not as yet shown much promise of success. Many striking episodes of the Gordon-Bennett balloon races at St. Louis were shown in moving pictures in which were seen the inflation of the enormous bags under the direction of a special detachment of the U. S. Signal Corps, then came also the actual start, the ascension and the shrinking of the balloon to a mere speck in the sky. A series of interesting slides was shown by Mr. Wilbur R. Kimball, a large number of slides being loaned by the Aero Club and by Mr. W. J. Hommer.

A PNEUMATIC DESPATCH EXHIBITION

The Pneumatic Transit Company upon the recent formal opening and adoption of a considerable extension of the postal pneumatic tube service in Philadelphia made the occasion an effective demonstration of the working of the system. About 200 invited spectators gathered at Station C, Nineteenth and Oxford streets, and saw the station transformed into a department store.

Hot tea, coffee and chocolate; roast turkeys

and other dishes; cakes, pastry, fruits and the dishes on which they were served to hundreds of guests; aquariums of gold fish, a chattering monkey, pigeons, cats, guinea pigs and animals, and articles of every description which could be snugly held in a steel tube measuring about thirty inches in length and nine inches in diameter, were ricochetted from one station to another terminating at Oxford street. A lighted candle encircled the city without becoming extinguished. None of the living things suffered from the experience.

From the main post office at Ninth and Chestnut streets each tube goes to Station O at Tenth and Columbia Avenue, thence to Station S at Sixth and Fairmount, to the Pennsylvania Railroad Station, to Station J, Nineteenth and North, and then along the last lap of the subterranean journey to the terminus at the Oxford Street Station.

THE LIMITATIONS OF AERIAL NAVIGATION

There is a good deal of misconception as to the probable field for successful aerial navigation. To the lay mind anything is possible, and the "navies battling in the blue" appears a reasonable probability of the future. The engineer, however, realizes the inherent dangers and difficulties of any form of air navigation. No invention or ingenuity can neutralize the danger to a body poised in mid air and dependent only upon the supporting power of the air to save it from a disastrous fall to the earth. No invention or ingenuity can make safe the navigation of a medium subject to such commotions as hurricanes and tornadoes. By no possibility can carriage of freight or passengers through mid air compete with their carriage on the earth's surface.

The field, then, for aerial navigation is limited to military use and for sporting purposes. The former is doubtful; the latter is fairly certain. As regards the former, it will be recalled that military balloons have been in use for more than half a century; and that modern high-power, long-range guns have greatly limited the usefulness of such methods of observation. There is every reason to believe that the same thing will limit the usefulness of the military dirigible balloon or flying machine. As for the use of any form of aerial navigation for carrying messages, the development of wireless telegraphy and telephony appears to have blocked all prospect of success there.

The sporting field is therefore the real field at which the flying machine inventor is aiming. Already ballooning and driving dirigibles are among the most popular fads of the sporting set in Paris. Aside from this the imitation of the birds has fascinated thousands and millions of people to an extent that makes it certain that the search for a successful flying machine will go steadily on, even though there be no prospect of great commercial returns to the inventor.—*Engineering News.*

A FORTUNATE SOCIETY

An esteemed contemporary announcing the results of one of the annual elections says:

The gentlemen named above are all eminently fitted to be officers of the American Institute of Mining Engineers. No better engineers are to be found than those mentioned, while the councilors are men of standing and prestige.

It should not be forgotten, however, that Dr. R. W. Raymond is the man who has made the Institute what it is. Through thick and thin, through good times and bad, in sickness and in health, Dr. Raymond has given his time and his intellect to the upbuilding of the Institute. It is his brain that makes the Transactions a standard of modern science; his personal magnetism that induces men to contribute gratuitously to the Institute material which they could sell elsewhere for much money; his power of management that has kept the Institute together, nipped in the bud all factional differences, and brought it from a small society to the front row of the technical societies of the world. For the last five years Dr. Raymond has been much afflicted with sickness; for weeks at a time he has suffered the most excruciating pain. Notwithstanding this fact, his zeal for the Institute has never lagged. He has done much of his work in bed, but the work has been done. Why is it that almost every great human accomplishment succeeds only by sapping some man's lifeblood? That every deed worth doing is done in spite of pain or loss or hardship?

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896

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NEW YORK'S COMPRESSED AIR HARVEST

Probably never was such a marvelous harvest as that which the city of New York is just now realizing from its compressed air plants. We speak now only of one group of these plants, the eighty air compressors which have been employed exclusively in subfluvian work and which have averaged much less than a decade of active service, and yet there are now six tunnels under the Hudson River and eight under the East River, all but two of which have a connected bore from shore to shore and four of which have been crowded with a continuous traffic from the days of their recent respective openings to the public, though neither has its completed traffic connections. The completion of each tunnel at once emphasizes the necessity for more, so that nothing is perhaps more certain than that numerous other tunnels will soon be under way, each upon completion to be immediately filled with the rushing currents of the city's life.

The first important compressed air plant, from which New York enjoys a perennial harvest was of course the New Croton Aqueduct. What could we do without it and how could we have had it without the air driven drills? Then there was the East River gas tunnel, the importance of which as a pioneer and educator in that line of work is not generally recognized, which more than justifies the sketch of the progress of the work which we present in our present issue. Here the compressed air, which was started in good faith merely to drive the rock drills, soon was saddled with a more serious and responsible function, that of opposing the pressure of the water, this double function since prevailing in all the subsequent tunnel work. Then came the subways, which, like the tunnels, all make the public immediately clamorous for more. In all these works compressed air has been the most conspicuous and responsible agency of construction and must continue so as long as we are permitted to see into the future. If anything may be said to be sure of constant employment anywhere it must be compressed air in New York.

A TYPICAL INVENTION

The initial act in the invention of the electric air drill, the first recognition or appre-

hension of the essential mechanical principle of its operation, would seem to have been a simple and easy thing, not that the simplicity of such an achievement, as regarded after the fact, in any way predicates the likelihood of its early accomplishment. All through the ages we have waited so long for the simplest things which we have been surprised with when they have appeared, and even then have been slow to appreciate them fully.

The realization of a novel invention is not unlike the catching of a fish, which is a simple enough trick, only that we have to wait, alert and prepared, until the fish comes along; and then the true fisherman's skill is not in getting the nibble, or even a bite that holds, but in landing the fish securely into the net of practical realization. The catching of a fish does not seem to typify the entire operation of successful invention satisfactorily. The patient working out of all the details of adaptation and practical employment, so that the new apparatus shall show decided advantages over all its predecessors, is quite another and a more protractedly laborious work than the first secure grasping of the idea.

In fishing for inventions, each catch is different from all which have been caught before, and after the capture many things remain to be learned, both those which have preceded it and those which will come after it, as one thing always leads to another. Each notable mechanical invention has been essentially a simple one in itself, but the study and development of its relations and adaptations have always employed many keen wits besides that of the so-called inventor.

At first it might be wondered why the plodding and faithful steam or air-driven rock drill should have been interfered with, and how a device so different in some of its essentials could possibly develop any advantages. In the first place, it may be hastily and honestly argued that the new electric air drill is a complicated arrangement as compared with the simple old rock drill. When the thing is looked into this objection becomes a self-evident absurdity, and the new device is a great simplification and effects a great reduction in the size and number of responsible parts. The drill itself has been reduced to its simplest terms and to the fewest parts; all the details of the old drill most complicated, most responsible, most trouble-begetting, most costly of maintenance, have been discarded, with no equivalent devices taking their place. The old drill implied a steam boiler or an air compressor, more or less distant, always entailing great losses in power development, and a costly pipe line to install and maintain and to extend as the work progressed. The new drill is complete in itself, carries everything with it, and its only connection is the electric wire, through which it asks for only one-third to one-fourth of the power formerly required to do the same work. In the actual doing of its legitimate work the new drill asks no odds of the old in any detail of its operation. It strikes a sharper, heavier blow, and more blows per minute. It solves completely the problem of employing the electirc current in rock drilling. That it will, therefore, soon knock out the steam or air drill is not to be expected, but that it will be making its way on its merits and that it will be taking the lead in new installations seems natural.

Like all new things, the electric air drill must at first be misunderstood and more or less misrepresented, often with honest intent by those who are not sufficiently or correctly informed. It is well worth investigating as a novelty and for its intrinsic worth.

A SPECIAL EDITOR FOR A. S. M. E. PROCEEDINGS

The American Society of Mechanical Engineers is rising to its opportunities, widening its field of usefulness, and augmenting its status as a national society, its latest important move being in the extending of the scope of its published proceedings. These have lately been taking the shape of a regular monthly periodical and now the publication is to have a recognized and responsible editor, in the selection of whom the society is to be heartly congratulated. Mr. Lester G. French has been appointed and has already entered upon his duties.

Mr. French was born in Keene, New Hampshire, in 1869, and very early commenced his training in editorial work and printing at Brattleboro, Vt., his father having been the publisher for a very long time of *The Vermont Phoenix,* and a partner in a large printing establishment in that place. In 1891 Mr. French received his degree in mechanical engineering from the Massachusetts Institute of Technology. After four years apprenticeship, drafting

room and shop experience, principally at the Builders' Iron Foundry shops in Providence, and a year and a half as a text book writer, Mr. French was engaged on the editorial staff of *Machinery,* assisted greatly in the development of that paper and for nine years was its editor-in-chief.

Among the immediate improvements to be undertaken is the establishing of departments in the monthly Proceedings, thus providing a greater variety of technical articles of interest. Many other features are planned and the aim will be to make the Proceedings of such value that no engineer can afford to be without them. All such papers, however, will first be presented and discussed before the Society at its meetings, as formerly, thus benefiting the membership two fold.

CORRESPONDENCE

COMPRESSED AIR LEAKAGE

Editor Compressed Air.

I have something on my mind. I have before me a copy of the first issue of *Reactions,* which is an attractive and valuable quarterly publication put out in the interest of the Goldschmidt Thermit Process of Welding. I want to give first some extracts from one article in it relating to compressed air transmission. It says:

"Few people realize that leakage plays an important part in the efficient operation of a compressed air plant. Many concerns will go to great expense in installing high class air compressors with compound steam cylinders and two stage air cylinders, but when it comes to installing the pipe line the utmost carelessness is displayed, the same fittings being used that would apply to a steam line without the fact being taken into consideration that steam and air are two very different mediums. The heat of the steam tends, of its own accord, to keep joints tight which if cold, would leak considerably."

The writer then goes into figures, considering successively the large central power plant, the plant of medium capacity, say for mines and quarries, and the small plant for manufacturing establishments. Of the first he says:

"This plant, while often very much larger, we will consider to have a capacity of 10,000 cu. ft. of free air per minute and assume that there is leakage of 1 per cent. or 100 cu. ft. of free air per minute. The horsepower required to compress 100 cu. ft. to 100 lbs. in a two-stage compressor would be 17.6 (allowing 15 per cent. for friction in the machine). Considering the cost of this power to be 2 cents per horse-power per hour, the cost of the leakage will be 35.2 cents per hour, or $3.52 per ten hour day, amounting to $1,056 at the end of the year of 300 working days. Even if the leakage only amounted to one-half of 1 per cent., the loss would come to over $500 per year."

The medium plant is similarly assumed to have a capacity of 1,000 cu. ft. of free air per minute and with a leakage of 1 per cent. as before the loss would be 35 cents per day or $105 per year. Now for the manufacturing plant:

"The plant is most frequently of a capacity of about 500 cu. ft. of free air per minute, but the percentage of leakage should be figured a little higher than in the previous plants, owing to the fact that more pains are taken with the larger and more expensive plants in the installation of machinery and piping than is the case with smaller and cheaper plants. Furthermore, most manufacturing establishments require a more complicated distribution of the compressed air and the installation of more valves, bends and outlets is needed. It is therefore more fair to consider the leakage as being 2 per cent. in these cases. The compressor will very likely be a single stage one and the horsepower required to compress the leakage of 10 cu. ft. per minute to 100 lbs. pressure will be 0.207x10=2.07. At 2 cents per horsepower per hour this leakage would cost 41.4 cents per ten hour day, or $124.20 per year."

The animus of this appears in the last sentence of the article:

"It is to counteract these losses that many concerns are now butt-welding the pipe joints in their compressed air and refrigerating pipe lines, thus producing a continuous line of pipe in which leakage is entirely impossible and the cost of maintenance eliminated."

Now, as to the loss by leakage. I have reason to believe that the above assumptions are exaggerations and that it is not so difficult nor so unusual as here represented to make piping airtight. The capacity of the usual air receiver represents about one minute's output of the compressor with which

it is associated, and the piping capacity will not average any more than that of the receiver, or altogether it might be said that two minutes' working of the compressor would fill the entire system from atmosphere up to full working pressure, and then when the compressor is stopped at night and in the morning the air pressure is still found there, which is the not infrequent occurrence, it is easier to realize how little air has leaked away than how much.

A handy, cheap and reliable welding process, which Thermit undoubtedly is, would, for compressed air practice, need to be accompanied by an equally handy, cheap and reliable *unwelding* process, for *all* air piping is not permanently installed, and the butt-welding of straight piping would not in any case eliminate the possible leakage, which occurs not in the run of the pipe but in valves, stuffiing boxes and other places where Thermit would not apply.

TECUMSEH SWIFT.

Editor *Compressed Air:*

In looking through your very interesting journal for February, my attention was attracted by the description of Mr. W. C. Stephens' double-edged chisel bit, and I note with considerable surprise that this gentleman is referred to as having introduced the "now indispensable hollow drill bit."

It may be a matter of interest to the writer of the article that hollow drill bits were in use nearly thirty years ago, and I have before me now the British Patent Specification of C. Pieper No. 22589 of 1879 in which the hollow steel bit and a delivery of water under pressure right through the drill from the back head forms an important item of the patent.

J. H. WETHERDON.

[The statement referred to was given upon the authority of the *Mining Journal,* London. —Editor COMPRESSED AIR.]

QUESTIONS AND ANSWERS

L. T., Providence, R. I., Q.: I have a gasoline engine about 4 H. P., single cylinder, two cycle, the cylinder 4-inch diameter by 4 1-2 inch stroke, with 80 pound flywheel. I wish to compress air on a small scale but to a high pressure, say 2000 pounds, and I am thinking of placing the compression cylinder, oc cylinders, directly behind the engine cylinder with one piston rod for all. I believe the working pressure of the engine would average about 70 pounds for the stroke, would it not? My question is as to the size of the compression cylinders. I suppose at once you would say in such small powers use a single cylinder, but it seems to me that with such high ultimate pressure, requiring a very small cylinder, that a secondary larger cylinder would facilitate the handling of more air. What should be the sizes of the two cylinders, and what should be the size of the single cylinder, if you decidedly think that one cylinder should be used? A: we decidedly think that not less than two cylinders should be used and three would be better; but the scheme as outlined has even then several elements of impracticability. The engine at 400 r. p. m. and at the 70 m. e. p. assumed for the working stroke would not show more than 3 brake horse power. With a piston rod carried out through the combustion chamber what kind of stuffing box and what packing would it be possible to use in the back cylinder head? The speed assumed would be high for such compression, but not perhaps impossible. An intercooler between the two stages of compression would be absolutely necessary and the arrangement as a whole would be so objectionable that it is not worth while to compute any cylinder sizes. Better leave the engine alone if it is all right and have a suitable belt driven compressor to go with it.

W. W. M., Pittsburg. *Q.*: I have prospective use for a pair of compressed air motors about as follows: 50 H. P. at 600 R. P. M., for continuous service in a coal mine, the load varying from 30 to 50 H. P., speed regulation to be within 10 per cent. and the motors to be entirely enclosed and self-lubricating. The less the space occupied the better; no reheating possible. I have at hand Mr. Richards', Mr. Hiscox's and Mr. Saunders' books on Compressed Air, but in neither of them can I find anything near the above requirements or any data relating to the air consumption of well-built motors in the above sizes. From the mass of compressor advertisements, and the amount of space devoted to the production of compressed air in the various books on the subject, and the corresponding lack of information on the motor end of the problem one

is naturally led to suppose that compressed air for the production of rotative motion is not in extensive use.

A.: The simple fact is that a steam engine makes such a perfect air motor that the compressed air people have no excuse for exploiting anything special for that purpose. You need a steam engine of suitable size with automatic cut-off governor, such an engine, for instance, as commonly used for electric lighting, and you will find that the engine will work better with air than with steam, and, of course, should regulate far within the 10 per cent. required. The tables in Richards' Compressed Air under "Power Value of Compressed Air," should give you all the data required for your computations. Use thin, limpid, *oily* oil, not as heavy as recommended for air compressors, and the lubrication will be found to be much better than with steam, as the oil remains on the surfaces much longer.

TRADE PUBLICATIONS

STEAM TURBINE MACHINERY. De Laval Steam Turbine Company, Trenton, N. J. 30 pages, 4½ by 7 inches. Numerous half-tones.

SHOP INSTRUCTIONS FOR THE USE OF THERMIT IN REPAIR WORK. Goldschmidt Thermit Company, New York, 32 pages 5 x 8 inches. Very complete detailed instructions are given with descriptions of apparatus required, quantity of material to be used, etc.

STEEL TIRES—CAUSES OF DEFECTS AND FAILURES. Standard Steel Works Company, Philadelphia. 38 pages 6 x 9 inches. This is a reproduction of a paper by George L. Norris, read before the Western Railroad Club with the discussion which followed and an editorial upon the subject from the *Railroad Gazette*. There are numerous fine half-tones showing fractures, etc.

LOCOMOTIVES BUILT FOR THE C. R. R. OF BRAZIL. Record No. 64, Baldwin Locomotive Works, Philadelphia, 32 pages 6 x 9 inches This describes the railroad system of Brazil and the various locomotives built for it by these works. The first locomotive was furnished in 1862, and up to date 326 have been built, their types representing the increasing demands of traffic and the successive improvements in design. Many of the engines were "narrow" or meter gage, but the larger number and for the principal lines were five feet three inches. It is intimated that a considerable business is realized by the works in supplying duplicate parts for the maintenance of this equipment.

PRACTICAL REFRIGERATION WITH A COMPRESSED AIR MOTOR

Revue Industrielle describes an interesting and profitable installation of an air motor in connection with a brewery in Paris, the public compressed air service, which is maintained in that city, being used to drive the motor for electric lighting purposes, and the exhaust being used for refrigerating with such success that the power and light service costs practically nothing.

The motor used is an old steam engine with early cut-off, the cylinder, built to metric measures, being 17.7 inches diameter; the stroke, 35.4 inches, and the normal speed 58 to 60 revolutions per minute. The engine has an unusually large exhaust pipe, 7 inches in diameter, so that its choking by freezing is thus avoidable. The motor drives a dynamo giving 300 amperes at 110 to 115 volts, which is capable of supplying 45 arc lamps, and 50 to 400 incandescent lamps, 10 to 16 candle-power. The motor runs 7 to 8 hours in summer and 10 to 12 hours in winter. It receives the air at 71 lbs., and at a temperature of 53 to 60 degrees Fahr., developing usually about 30 horse-power, which on Sunday may go to 40 or 45 horse-power. Glycerine is used for lubrication, its presence in the air being less objectionable than that of oil.

The theoretical difference of temperature between admission and exhaust would be about 176 degrees, and the exhaust actually goes as low as—76 degrees, Fahr. The lowest temperatures reached are, of course, in the winter, and after long continuous operation.

The exhaust pipe is passed through the basement, discharging into the freezing chamber toward the bottom of that room. This chamber is divisible into two parts by a movable partition, and the part receiving the exhaust directly is the freezing com-

partment, while the other is used for storing ice. The walls, ceiling and floor of both compartments, as well as the exterior wall of the beer cellar, are made of blocks of ground cork covered with wood sheathing. The freezing room and the ice storeroom are each 9.8 feet long, 14.75 feet wide, and 5.75 feet high. The beer cellar is designed to hold about 2,650 gallons of beer in barrels.

The exhaust pipe expands from its general diameter of 7 inches to a diameter of 15¾ inches in the wall of the freezing chamber. The water for freezing is placed in cans containing 22 pounds each. The air for cooling the beer cellar passes from the freezing room in a pipe 15¾ inches in diameter and extends some distance within that room. In the passageway separating the cellar from the freezing room a subdivision is made in this pipe, one branch going to the cellar and the other connecting with a riser pipe discharging to the atmosphere. A butterfly valve is inserted in both branches for regulating the air supply to the cellar, so that it is possible to vary the volume of cold air passing into the cellar according to the needs by by-passing a portion of the total flow to the atmospheric discharge.

The utilization of the exhaust from the compressed air motor which drives the lighting unit thus furnishes both ice and cold which it would otherwise be necessary to purchase. The compressed air costs at the rate of 4.45 cents per 1,000 cubic feet, and the consumption per horse-power is about 847 cubic feet. The net cost per kilowatt-hour under these conditions amounts to 6.3 cents, indicating an efficiency of nearly 80 per cent. for the machine. Ice costs 44.7 cents per 100 lbs. It is stated that for cooling the cellar 0.415 pound of ice would be required per gallon on the basis of 7 hours operation in summer, or 1,100 pounds for the 2,650 gallons of beer which it holds. This means 157 pounds would be required per hour. The production of ice per horse-power per kilowatt-hour amounts to 14 pounds. This means that when the lighting unit is supplying 300 amperes, or in other words an output of 34.5 kilowatts per hour, that the ice capacity is 485 pounds in one hour. The cost of this ice at 44.7 cents per 100 pounds is $2.17. The cost of the compressed air at 6.3 cents per kilowatt-hour for the 34.5 kilowatt-hours amounts also to $2.17. This indicates that the lighting service costs nothing, the unit supplying an amount of ice that would cost if purchased what the compressed air actually accepted did cost.

MISLEADING EFFICIENCIES

It is unfortunately true that the word "efficiency" has not so definite a meaning as we might hope. Ordinarily the word implies a ratio between the measure of an effect and a cause. It may be the ratio of the energy delivered in the form of useful work in foot-pounds to the energy supplied in the same form at a shaft, or to that supplied in the form of water under pressure, in the form of heat in steam, or heat in coal. The useful effect may not be measured in foot-pounds, but in some other unit subject to just as great variety in the form of expression as the energy supplied. Quite as often, however, is the word applied to the ratio of useful effect not in the form of energy to some unit of supply. Thus, in ice making plants the weight of ice produced per ton of coal is often used as one measure of the efficiency of the plant, but it by no means represents the thermodynamic efficiency considered of the ratio of the energy abstracted from the system to the energy supplied. In blast furnace practice the ratio of the weight of iron produced to the coke supplied, and with excavating machinery the weight of coal used per cubic yard excavated, might be cited as measures of efficiency that are not energy ratios, though perhaps involving them.

In still another sense is the word efficiency used; as the ratio of values or weights or other quantites; thus for pumps, the ratio of the volume of water pumped to the piston displacement; and in compressors, the ratio of the cubic feet of gas or vapor at the suction pressure to the piston displacement, are examples of volumetric efficiency entirely independent of the energy employed. The efficiency of a business might be, and is often measured by the earnings. Quite frequently, though loosely, the efficiency of a man is a matter for consideration, implying, when so used, the mental comparison, consciously or unconsciously, and his accomplishments in some line of work with those of other men similarly employed, as his general effectiveness.

Efficiency is sometimes used in this general sense of effectiveness without implying a ratio of effect and cause at all, but rather implying a unit of capacity. Thus, the efficiency of heating surface is often referred to, but what is meant is the capacity of that particular surface for transmitting heat. It seems rather unfortunate, therefore, that a purchaser or even an engineer should be led to believe that so indefinite a word or term is employed as an element in the judgment of the value of machinery. Any purchaser of machinery is essentially an investor of capital who expects to make money by supplying some market with a commodity, in the production of which machinery plays but a part. For such a purchaser, or plant owner, one style of machinery is better than another only when the cost of its operation is less per unit of product, that cost being properly computed, and including the cost of all raw material for operation directly and indirectly for repairs and maintenance, together with the labor for operation, maintenance and superintendence to give the total operating cost. To this is to be added the fixed charges, involving interest and depreciation, insurance, taxes, and in the case of interruption to business by breakdowns or losses of capacity, a sum in the nature of damages or deferred profits. It makes not a particle of difference to such an owner of an ice or refrigerating plant whether his steam engine has a thermal efficiency of 5 per cent. or 10 per cent., or his boiler 60 per cent. or 70 per cent., whether his compressor has a volumetric efficiency of 70 per cent. or 100 per cent., provided the cost of his product, which is not steam or gas power or pumpage, but ice or refrigerated rooms, be properly low.

The commercial value of machinery is, therefore, not to be found in the thermal, mechanical, volumetric or other efficiency of any part alone, nor in the efficiency of the whole necessarily, but only in the earning power of the plant. It is essential, however, that this earning power be properly and not partially computed, and be measured not only over a month or a year, but for all time.

The manufacturer of machinery must be ever on guard to avoid being misled by false standards of value, and there are plenty of illustrations showing the fact that earning power and not thermal, mechanical, volumetric or any other standard of efficiency, must control and does control in the long run its construction, purchase, sale and operation, however much the latter may be useful as guides.

The most efficient heat engine on the market is the Diesel oil engine, which converts between 30 per cent. and 40 per cent. of the energy of the fuel into work at the shaft. Why, then, are not all steam, gas or other oil engines scrapped or driven from the market? The most efficient steam engines are of the multiple expansion, condensing type with superheated steam. Why do they then not displace all others? The most efficient blower is of the piston type. Why, then, are rotary blowers and fans still built and sold in such great quantities? Copper is, of the baser metals, by far the best conductor of heat, and very much better than iron or steel. Why, then, are not all boilers, feed water heaters, condensers, expansion coils, brine coolers, refrigeration coils, steam heating radiators, economizers and other heat transfer apparatus made of copper?

The answer to these and all other similar questions is to be found in the fact that other and more important conditions of cost, adaptability to the service or to particular locations, ability to use available sources of supply, adaptability to skilled or unskilled labor, to continuous or intermittent operation, life of the apparatus, and many others, requiring a broader and more difficult judgment and involving a more complicated criterion than any single efficiency, enter into the solution.—Prof. Charles E. Luck in *Ice and Refrigeration.*

Sir David Gill in a recent address said that the atmosphere of Mars is so rare that the temperature must be much lower than our own, so much so that some people had imagined that the snow caps were made up of frozen carbonic acid. He had never himself seen the canals which certain astronomers had spoken of, but, granted all that, he failed to see the remotest proof of habitation by man. He did not deny the existence of some kind of animals very different from ourselves, but he saw no proof of the work of any human beings on the enormous scale which had been talked about.

APRIL MEETING OF THE MECHANICAL ENGINEERS

The next monthly meeting of The American Society of Mechanical Engineers will be held in the auditorium of the Engineering Societies Building, New York, on the evening of April 14. The general subject of the meeting is The Conservation of our Natural Resources, which is now receiving unusual attention, because of the invitation of the President of the United States to the governors of the several states, and to the presidents of the national engineering societies, to confer with him in Washington on this important problem. The meeting will be addressed by four speakers who will consider forest preservation in its relation to water power, economy in the utilization of fuels, and the attitude of the engineer in regard to these. Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching, will be one of the speakers and will discuss the "Relation of the Engineer to the Body Politic."

NOTES

A bill providing for the creation of a Bureau of Mines will be reported to the House of Represenatives at Washington at an early date. The only question undecided by the committee having the bill in charge is whether the bureau shall be under the jurisdiction of the Secretary of Commerce and Labor or the Secretary of the Interior.

Three aeroplanes will be contracted for by the Signal Corps of the United States army. The successful bidders, with their prices and time of delivery, are: Wright Brothers, Dayton, Ohio, $25,000, delivery in 200 days; A. M. Herring, New York City, $20,000, 180 days; J. F. Scott, Chicago, Ill, $1,000, 185 days. Of 41 bids which were received these three were the only ones that followed the Signal Corps specifications. The surprise bid was that of Mr. Scott, who, through patriotism, agreed to build a satisfactory machine that will fly for the mere cost of material.

The following method of thawing dynamite is recommended: Prepare a strong wooden box of the size required and line it with cloth. Have a tight fitting lid and place in the center of the box a can, which is also covered tightly. Then place hot water in the can and cover that. Place the powder in the box and heat from the can of hot water will thaw the dynamite gradually and thoroughly, and then it can be kept for hours in a convenient place ready for use. The tight cover will retain the heat in the box for a long time and all danger will be removed.

In Denmark they have time and seem to think it pays to seriously experiment with windmills for the development of electric power. Four wings are said to give the best results. With a sail area of 48 square meters (57.4 square yards) and a wind velocity of 6 meters per second (13.4 miles per hour) 8 horse power is obtained. With a "No. 3" wind (17.88 miles per hour) which is not unusual, the horse power is doubled.

Professor G. Frederick Wright says that at the beginning of the Christian era the edge of the Horseshoe cataract at Niagara was 1¾ miles lower down than now and at the time of the Trojan War it was at the head of the whirlpool rapids, nearly three miles below. At the period of human history marked by recent discoveries in Egypt and Babylonia this marvellous cataract was just beginning its work of erosion, while Canada was as well within the grasp of the glacial epoch as Greenland is to-day.

M. Charles Féry has constructed a very simple calorimeter for determining the calorific power of gases and liquids. The combustion is effected at the base of a glass chimney, the top of which supports a nickel plate pierced with a number of holes. The air necessary for combustion passes down a similar chimney, which is connected at its base with the former. The two junctions of a constantan-copper thermo-circuit are placed at the tops of the chimneys, and the electromotive force in the circuit is exactly proportional to the calorific power of the combustible and to the volume of it consumed in unit time.

Electrical air filtration is suggested by an English experimenter, who has discovered that a body positively electrified to 100 volts or over will, if placed in a sooty atmosphere, become covered with soot in a day, while a negatively charged body remains comparatively clean. In an application of this discovery to the fan intake of a ventilating system; a sheet of wire gauze was inserted in the

intake flue, and electrified by connection to the positive of a 250-volt supply main. The gauze is reported to have extracted large quantities of soot from the air.

Mercury spilled on a table or floor is somewhat hard to collect, unless special precautions are taken, owing to its tendency to divide into small globules, which roll away at the slightest touch. If a wet ring is made round the spilled mercury by the aid of a wash bottle or other similar means, it will be found that the globules of mercury cannot readily cross this ring; the mercury can then be collected in a small shovel made from a piece of thin card, or even an ordinary envelope.

The question of how deep mining operations may be carried is much discussed, but has never been determined, except locally. In some instances it has been determined by economic conditions; in others by physical conditions, such as large floods of hot water, or high temperature of the air. From a mechanical standpoint equipment can be provided which will enable the sinking of shafts and the operation of mines to a depth approximating 10,000 feet. At present, about 5,000 feet is the limit. It is probable that the only inducement required to carry mining operations to a depth of two miles is rock sufficiently rich to pay the cost.

Wind pressure varies with the square of the velocity of the wind, but there is as yet no agreement as to the constant in the formula. According to Smeaton, $P=0.005V^2$; according to Martin $P=0.004V^2$; according to Whipple and Dines, $P=0.0029V^2$; where P is the pressure, when the surface is at right angles to the direction of the wind, in lb. per sq. ft. and V is the velocity in miles per hour. At 60 miles per hour these formulæ give the pressure in lb. per sq. ft. as 18, 14.4, and 10.44, respectively. The Smeaton formula is generally accepted as correct for small surfaces such as used in wind-mill practice, but it gives too large results for large solid bodies. The Smeaton formula is used by the U. S. Signal Service.

There is an immense traffic in wine on the Italian railroads; but the consignees this year complain bitterly of the "evaporation" from the casks en route. In a single fortnight a Milan firm found one cask with a gimlet hole and 25 gallons short; another with bung out and also 25 gallons short; three broken open with 60 gallons missing, and another which lacked the bung and 20 gallons of wine. These calamities are doubtless due to the failure of the railroads to keep a supply of water on their freight trains. From time immemorial it has been the custom of wagoners hauling wine into Rome (and doubtless other places) over the Campagna in the heat of the day to take their siesta under the shade of the cask, provided with a gimlet. But they always delivered the casks full, which was easy to do because further on the evaporation could be made good from the aqueducts.

At the recent meeting of the American Society of Heating and Ventilating Engineers, Mr. H. W. Whitten gave an account of tests made to determine the air leakage of ordinary windows. He found that with a wind pressure equal to 0.1 in. of water outside a window and a 1-32-in. clearance between window frame and sash, 105 cu. ft. of air were driven per hour through each lineal foot of such clearance space, while with a 1-16-in. clearance, the leakage was 184.8 cu. ft. per hour. With other windows, equipped with good metal weather strips and subjected to the same pressure, the leakage amounted to no more than 12 cu. ft. per lineal foot per hour. In tests made with a pressure of ½ in. of water, which corresponds to a wind velocity of 24 miles per hour, leakages were noted of 179 cu. ft. per lineal foot for 1-32-in. clearance, 402 cu. ft. for 1-16-in. clearance, and 45.6 cu. ft. for the sash with the metal weather strips. With a pressure double that used in the latter case, equivalent to a wind velocity of 48 miles per hour, the leakages were 432 cu. ft., 591.6 cu. ft. and 69 cu. ft.

Dr. Gans, of Garmisch, near Munich, chairman of the airship section of the Bavarian Automobile Club, has offered a prize of 10,000 marks, ($2,380) to be awarded to a flying machine, between May 1, and October 1, 1908, during the Munich Exhibition. Competitors of any nationality are eligible for this prize. The prize will be awarded to the aeronaut who, starting from the ground, succeeds in

flying or remaining suspended in the air above the space assigned to him for the purpose, for 10 min., and in landing within that area after the 10 min. have elapsed. Balloons or flying machines fitted with balloons are not eligible for competition. Intending competitors must enroll their names on the list in the office of the Sports Committee of the Exhibition, "Munich, 1908," and send a description of their flying machine, accompanied by a photograph or sketch and pay an entrance fee. Further details may be had by applying to the office of the Sports Committee of the Exhibition, "Munich, 1908," 10 Neuhauserstrasse, Munich, Germany.

Reporting from Hanover, Consul Robert J. Thompson says that a newly invented refrigerating apparatus, a model of which has recently been privately exhibited in that German city, promises good results. The device is an extremely simple and inexpensive affair, costing perhaps not more than $1 to manufacture. It consists of a double-wall tin vessel with a capacity of 5 gallons or more. There is a hollow space between the two walls, or inner and outer vessels. This space completely surrounds the inner compartment and is about an inch in width. By the graduated admission of carbonic acid to this surrounding chamber at the bottom of the vessel, and from this surrounding chamber into the vessel proper at the top through a cross-armed tube, the contents of the vessel are frozen quickly and completely. Water is changed into ice in the space of sixty seconds. Meats, fruits, bottled beverages, may be chilled or frozen in a few seconds. But then you must have your supply of carbonic acid, so that it's not so cheap and handy after all as would seem to be implied above.

One of the first attempts at accurate measurement for furnace temperatures was by means of Seger cones. These are slender cones several inches in height, molded from some refractory material, such as clay, mixed with other substances in such proportions that cones having different melting points are obtained. A measurement of the high temperature is made by placing a number of the cones, having graduate melting points, in the furnace or kiln. Some of the cones may melt down while others are unaffected. The one which shows incipient fusion will register very close to the temperature of the furnace. Pyrometers of various types are much used in high-temperature measurements, the thermo-electric pyrometer being, perhaps, the most popular in the United States. This instrument is based upon the principle of the thermo-electric couple. In it two dissimilar metallic conductors are joined and connected in electric circuit with a galvanometer. The couple is inserted into the furnace when an electric current is generated which produces a deflection of the galvanometer needle, the amount of which deflection depends on the temperature.

LATEST U. S. PATENTS

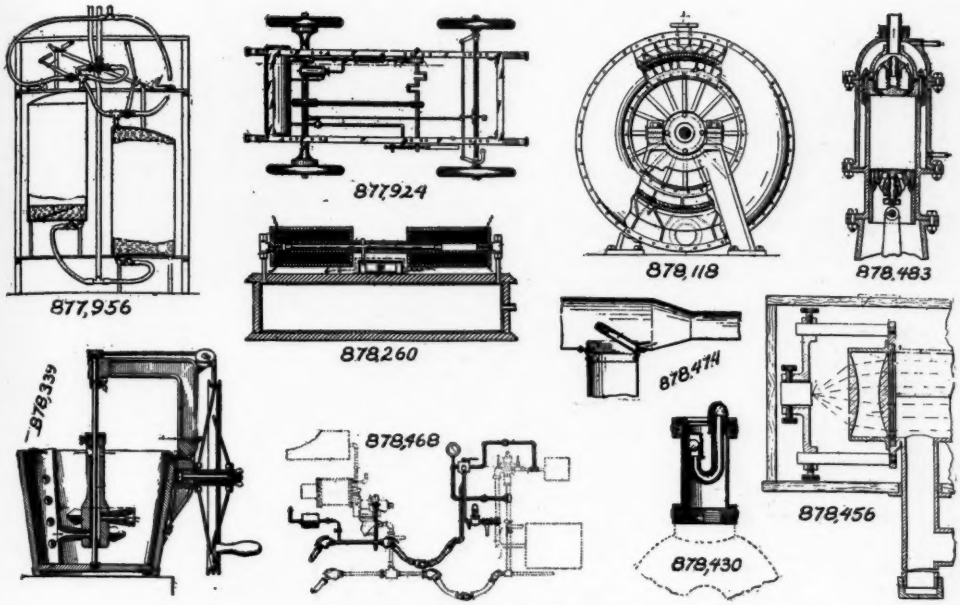
Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

FEBRUARY 4.

877,924. AIR - COMPRESSOR MECHANISM FOR SELF-PROPELLED VEHICLES. ERNEST E. HAMPTON and CICERO G. SMITH, Palisade, Colo.
877,956. WATER - ELEVATOR. MILO R. SHOURDS, North Powder, Oreg.
878,118. EXPANSIBLE - FLUID TURBINE. BENJAMIN S. CHURCH, New York, N. Y.
878,260. ELECTRIC AIR-COMPRESSOR. NELSON M. WATSON, Detroit, Mich.
878,339. AERATING - CHURN. EDWIN H. BURNES, Amsterdam, N. Y.
878,430. ANTISIPHON-VALVE. WILLIAM B. THOMPSON, Charleroi, Pa.
878,456. AUTOMATIC APPARATUS FOR DETECTING SMOKE AND THE LIKE. HORACE DARWIN, Cambridge, England.
878,468. AIR-BRAKE. WILLIAM G. PATTEE, Minneapolis, Minn.
878,474. VENTILATING DEVICE. JAMES L. WATERBURY and CLYDE WATERMAN, Minneapolis, Minn.
878,483. ICE-MACHINE COMPRESSOR. CASPER W. MILES, Cincinnati, Ohio.

FEBRUARY 11.

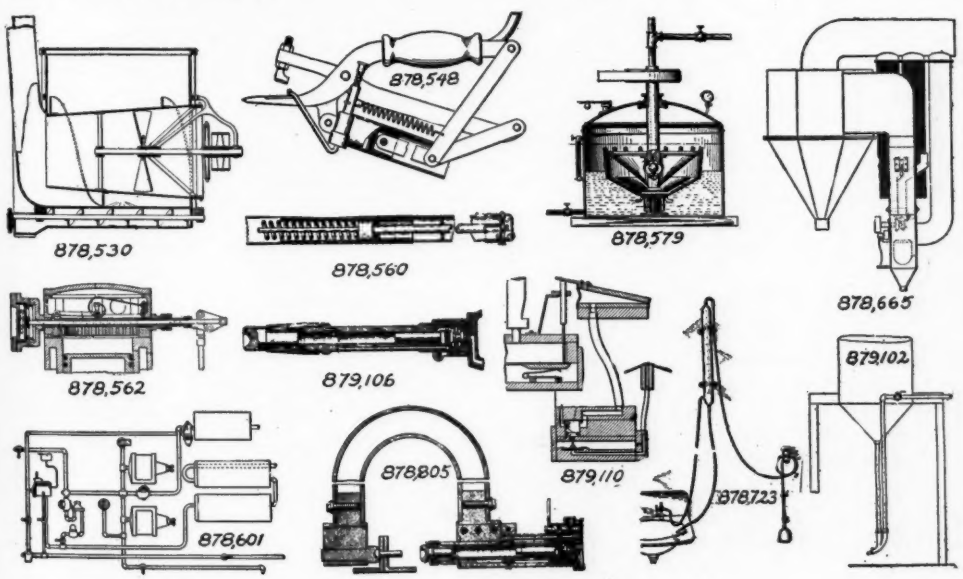
878,530. PNEUMATIC STACKER. ANDREW J. INGLIS, Chicago, Ill.
878,548. PNEUMATIC TOOL. GROSVENOR D'W. MARCY, Dorchester, Mass.
878,560. AIR-GUN. DAVID F. POLLEY, Plymouth, Mich.
878,562. VALVE MECHANISM FOR COMPRESSORS. SIDNEY A. REEVE, Worcester, Mass.
878,579. AIR-COMPRESSOR. LAMARTINE C. TRENT, San Francisco, Cal.
878,601. AIR-BRAKE APPARATUS. HENRY F. BICKEL, Plainfield, N. J.
878,723. VACUUM APPARATUS. STEPHEN E. GRIGGS, Seattle, Wash.
878,805. PNEUMATIC RIVETER. JULIUS KELLER, Philadelphia, Pa.
879,102. SAND-BLAST APPARATUS. JOHN F. HAY, Erie, Pa.
879,106. PNEUMATIC HAMMER. JULIUS KELLER, Philadelphia, Pa.
879,110. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. CHRISTIAN MAERTEN, Jr., Martinsville, N. Y.



PNEUMATIC PATENTS FEBRUARY 4.

FEBRUARY 18.

879,213. AIR COMPRESSOR OR PUMP. WILLIAM H. TEW, Glasgow, Scotland.
879,227. PNEUMATIC MOTOR. CHARLES G. WIELAND, Hoboken, N. J.
879,267. CONTROLLING MEANS FOR PNEUMATICALLY-OPERATED DEVICES. RAY P. JACKSON, Wilkinsburg, Pa.
879-273. AIR-PURIFYING APPARATUS. JOHN H. KINEALY, Ferguson, Mo.
879,392. SYSTEM OF COOLING ROOMS BY COMPRESSED AIR. OLIVIER LEVILLY, Paris, France.
879,472. GAS-PRESSURE REGULATOR. PETER KELLER, Chicago, Ill.
879,748. ELASTIC-FLUID TURBINE. CHARLES G. CURTIS, New York, N. Y.
879,771. PNEUMATIC GIN-FEEDER. ROBERT L. HOLLINGSWORTH, Decatur, Ga.
879,779. AIR-SHIP. EDGAR F. LEEDS, Mount Carmel, Ill.



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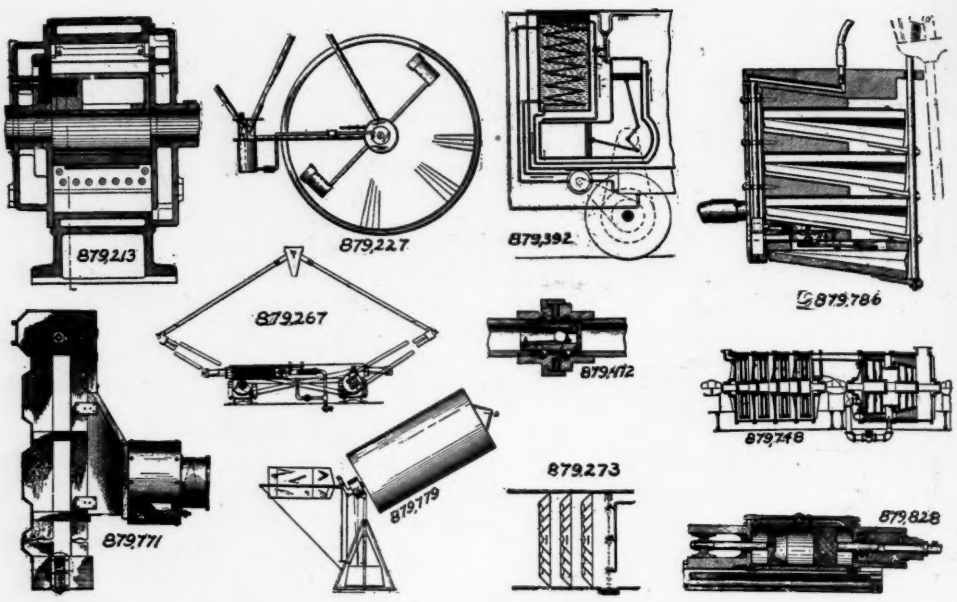

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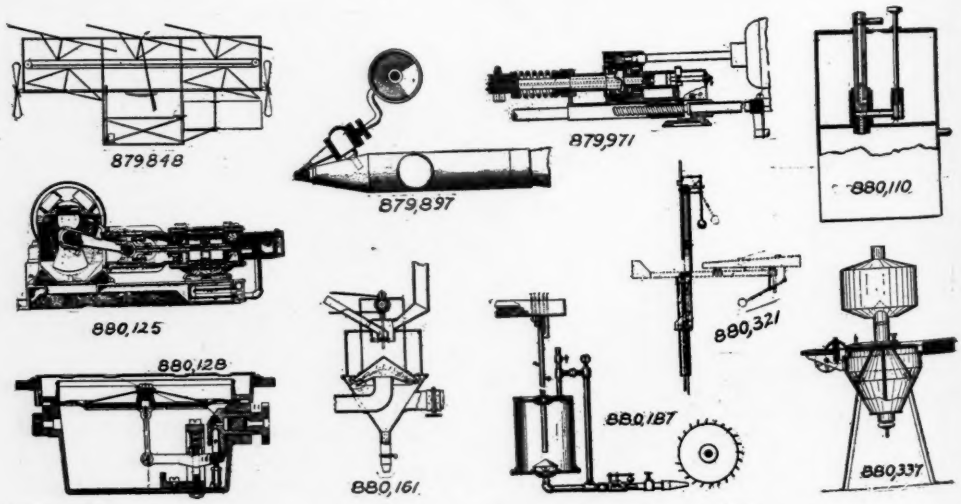
879,786. PNEUMATIC ACTION. HERMANN MEYER, New York, N. Y.
879,828. ELECTROPNEUMATIC DRILL. OLIN S. PROCTOR, Denver, Colo.

FEBRUARY 25.

879,848. AEROPLANE. GEORGE H. BENEDICT, Chicago, Ill.
879,891. AIR-BRUSH. JENS A. PAASCHE, Chicago, Ill.
879,971. ROCK-DRILL. BRADFORD H. LOCKE, New York, N. Y.
880,110. ACETYLENE - GAS GENERATOR. LEON SUSSMAN, Bayonne, N. J.
880-125. COMPOUND AIR - COMPRESSOR. NIELS A. CHRISTENSEN, Milwaukee, Wis.
880,128. PRESSURE-REGULATOR. ROBERT M. DIXON, East Orange, N. J.
880,161. AIR AND DUST SEPARATOR. WILLIAM S. OSBORNE, Marietta, Pa.
880,187. HYDRAULIC AIR - COMPRESSOR. ROBERT I. BLAKNEY, Seattle, Wash.
880,321. WIND-MOTOR. DANIEL D. MCINTYRE, Bucklin, Kans.
880,337. SAND-BLAST MACHINE. GEORGE S. SLOCUM, Newport, R. I.



PNEUMATIC PATENTS FEBRUARY 25.